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POCKET COMPANION.

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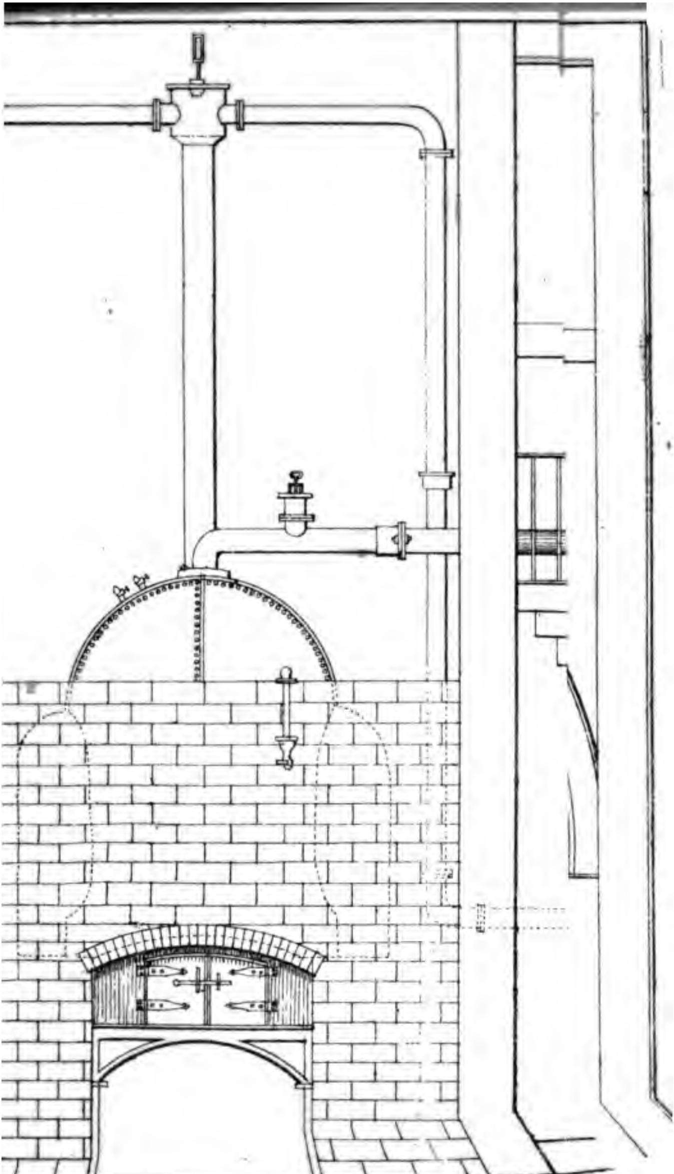

THE

MILLWRIGHT AND ENGINEER'S

POCKET COMPANION;

COMPRISING

DECIMAL ARITHMETIC,
TABLES OF SQUARE AND CUBE ROOTS,
PRACTICAL GEOMETRY,
MENSURATION,
STRENGTH OF MATERIALS,
MECHANIC POWERS,
WATER WHEELS,
PUMPS AND PUMPING ENGINES,
STEAM ENGINES,
TABLES OF SPECIFIC GRAVITY,
&c., &c., &c.

TO WHICH IS ADDED,

AN APPENDIX;

CONTAINING THE CIRCUMFERENCES, SQUARES, CUBES, AND AREAS OF CIRCLES, SUPERFICIES AND SOLIDITIES OF SPHERES;
&c., &c., &c.

SEVENTH EDITION,
WITH ADDITIONS AND CORRECTIONS.

BY WILLIAM TEMPLETON,

Author of "The Engineer's Common-place Book of Practical Reference," "Locomotive Engine Popularly Explained," and "Mathematical Tables."

WITH LITHOGRAPHIC ILLUSTRATIONS.

LONDON:

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1846.

ADVERTISEMENT.

In introducing this small work to the notice of the public, the Author has merely to state that it was undertaken with a view to facilitate the calculations of Millwrights, Engineers, Ironfounders, &c., and by them it is to be hoped it will be duly appreciated, more especially when they consider that the subjects treated of (with very few exceptions) have been diffused throughout a number of valuable and extensive works, quite out of the reach of mechanics in general, and too voluminous to be made useful where they were most required. Indeed, the greater part of mechanical works have been swelled out by theoretical problems, too tedious for practical men,—a defect which is here obviated, by commencing with a system of decimals, and carrying on the work throughout entirely on that system.

With regard to the subjects selected, no comment is necessary, as every mechanic is well aware that one or other of them is required daily; and the reader will find the book, though small, to be interspersed with various original and useful rules, well adapted for mechanical calculations.

Liverpool, July, 1832.

ADVERTISEMENT TO THE SECOND EDITION.

It is, undoubtedly, a source of gratification to an author to find that his labours have been duly appreciated by a discerning public; and this, it may be inferred, has been the case with the Author of the "Millwright and Engineer's Pocket Companion," the first edition having been disposed of in little more than twelve months; and a second edition being called for, he has been induced carefully to revise it, and greatly to augment it with other useful matter;—among which will be found, Tables of Square and Cube Roots, Strength of Materials, Tables of the Circumferences and Areas of Circles, &c.,—hence it is anticipated that these improvements, combined with the former practical rules which it contains, will render it a still more useful companion to mechanics, and men of business in general.

Liverpool, September, 1833.

ADVERTISEMENT TO THE THIRD EDITION.

The object of this work is to combine (in as small a compass as is compatible with the importance of the various subjects it embraces) and to facilitate the daily calculations of Millwrights, Engineers, Ironfounders, and Mechanics in general; hence, correctness is the basis of its claim to merit. The Author, being aware of this, and finding, in a great measure, that his labours have met his expectations, by the rapid sale of two editions, has been induced to revise the work throughout; and where personal experiment and practice have overthrown old rules, to introduce new ones, in accordance with the most celebrated machinery: being aware, also, of the general application of decimal arithmetic to mechanical calculations, he has been induced to commence the work with its principal leading rules, and to form each succeeding rule and table upon that system.

Several very important rules have been added, and various rules of not so much importance made approximates, by which the work will become more generally useful, and, at the same time, not more bulky, so that it may still retain the name of a useful Pocket Companion.

November, 1835.

ADVERTISEMENT TO THE FIFTH EDITION.

The success which has attended the former editions of this work is the surest testimony of its utility; consequently, no apology need be offered for again bringing it before the public.

In preparing the fifth edition the utmost care has been exercised, and several additions have been made, which, it is hoped, will render the work still more acceptable and useful to the practical mechanic, for whose especial use it was originally published.

May, 1839.

ADVERTISEMENT TO THE SIXTH EDITION.

The merits of a work are best appreciated by its extensive sale and unremitting demand; of these, the present work has had a considerable share, five editions having already been sold off, leaving still a pressing demand; hence, in order to render it of still greater utility, and, consequently, more deservedly popular, the Author conceived the necessity, previously to bringing out a sixth edition, of carefully examining the whole throughout, not only for the purpose of correcting any trifling errors that might have crept in during the reprinting of the various editions, but also with a view of adding a considerable portion of new matter, which has been obtained through the advancement of mechanical science since the work was first introduced to public notice.

Amongst the additional information will be found a variety of useful notes, and many new problems in geometry and mensuration, also various new tables, and several of the former considerably augmented; in fact, the work is in a great measure remodelled, so as to keep pace with the vast improvements in that department of science to which it professes to belong. Hence, it is presumed, in consequence of the great care which has been bestowed in the revision of the work, and the quantity of practically useful matter added, it will be found not only to support the character which it has already attained, but that its value will be still further enhanced in the estimation of the public.

August, 1841.

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THE

MILLWRIGHT AND ENGINEER'S

POCKET COMPANION.

AN EXPLANATION

OF THE SIGNS OR CHARACTERS NOW GENERALLY MADE USE OF IN ALL SORTS OF CALCULATIONS.

$=$	signifies Equality, as......	4 added to 3 is equal to 7.
$+$	signifies Addition, as........	$5 + 3 = 8$.
$-$	signifies Subtraction, as	$5 - 3 = 2$.
$\times$	signifies Multiplication, as	$5 \times 3 = 15$.
$\div$	signifies Division, as	$15 \div 3 = 5$, or $\frac{15}{3}$.
$: \,::\, :$	signifies Proportion	as 2 is to 3, so is 4 to 6.
$\sqrt{\ }$	signifies Square Root, as	$\sqrt{9} = 3$.
$\sqrt[3]{\ }$	signifies Cube Root, as	$\sqrt[3]{27} = 3$.
3^2	signifies that 3 is to be squared, as......	$3^2 = 9$.
3^3	signifies that 3 is to be cubed, as	$3^3 = 27$.

$\overline{3 + 5} \times 3 = 24$ the Bar signifies that two, three, or more numbers are to be taken together, as 3 added to $5 = 8$, and 3 times $8 = 24$.

$\sqrt{5^2 - 3^2} = 4$ signifies that 3 squared taken from 5 squared, and the square root extracted $= 4$.

$\sqrt[3]{\frac{20 \times 12}{30}} = 2$ signifies that when 20 is multiplied by 12, and divided by 30, the cube root of the quotient $= 2$.

OF WEIGHTS AND MEASURES.

Avoirdupois Weight is the only weight made use of in mechanical calculations; and all metals, save gold and silver, are weighed by it: hence, it is not requisite here to take any other into consideration.

				Fr. Grammes.
	=	1 Dram	=	1.771
16 Drams	=	1 Ounce	=	28.346
16 Ounces	=	1 Pound	=	453.544
28 Pounds	=	1 Quarter	=	12.699 kilog.
4 Quarters	=	1 Hundred wt.	=	50.796 „
20 Hundred wt.	=	1 Ton	=	1015.920 „

NOTE.—5760 Troy grains = 1 pound Troy; and 7000 Troy grains = 1 pound Avoirdupois; hence, 175 pounds Troy = 144 pounds Avoirdupois.

Or, Avoirdupois	lbs. × 1.21527	=	Troy lbs.
Do.	ounces × .9115	=	Do. ounces.
Troy	lbs. × .823	=	Avoir. lbs.
Do.	ounces × 1.1	=	Do. ounces.
Do	grains × .03657	=	Do. drams.
Also, Avoirdupois	lbs. × .00893	=	Cwts.
And, Do	lbs. × .000447	=	Tons nearly.

TABLES.

Showing the relative Proportion between Foreign Weights and the Avoirdupois Pound.

1. FRENCH WEIGHTS.—DECIMAL SYSTEM.

1 Milligramme	=	.0154 Troy grains.
1 Centigramme	=	.1543 „
1 Decigramme	=	1.5434 „
1 Gramme	=	15.4340 „
1 Decagramme	=	154.3402 „
1 Hectogramme	=	1543.4023 „
1 Kilogramme	=	2.20486 lbs. Avoirdupois.
1 Myriagramme	=	22.0486 „
1 Quintal	=	1 cwt. 3 qrs. 25 lbs. nearly.
1 Millier or Bar	=	9 tons. 16 cwt. 3 qrs. 12 lbs.

2. SYSTEME USUEL.

The Kilogramme	= 1000	Grammes	= 2 lbs.	3 oz.	4½	Dr. Av
The Livre Usuel	= 500	,,	= 1 ,,	1 ,,	10¼	,,
The Half	= 250	,,	=	8 ,,	13⅛	,,
The Quarter......	= 125	,,	=	4 ,,	6½	,,
The Eighth	= 65.5	,,	=	2 ,,	3¼	,,
The Once	= 31.3	,,	=	1 ,,	1¾	,,
The Half	= 15.6	,,	=		8⅞	,,
The Quarter......	= 7.8	,,	=		4½	,,
The Gros	= 3.9	,,	=		2¼	,,

3. VARIOUS FOREIGN WEIGHTS IN POUNDS AVOIRDUPOIS.

Places & names of weights.	Lbs.	Places & names of weights.	Lbs.
Alexandria } rotola forfora....	.9347	Genoa........peso sottile	.6938
,, rotola zaidino	1.335	,, peso grosso	.7687
,, rotola zauro..	2.07	Hamburgh........pound	1.068
,, rotola mina ..	1.67	Havannah........pound	1.075
Amsterdam....old pound	1.09	Leghorn...........pound	.764
,, new ditto	2.206	Madras...............vis	3.125
Antwerp.......old pound	1.033	Malabar............vissay	3.001
,, new ditto	2.206	Malta ....rotola	1.745
Bahia, Lisbon, and Oporto } Aragal	1.012	Mocha ....rotola	1.125
Barcelona...........pound	.882	Mogadore } commercial pound.	1.19
Batavia..............cattie	1.36	,, market pound	1.781
Bergen..........., Christina, and Copenhagen... } pound	1.1025	Naples ....rotola	1.965
Bombay...............seer	.7	Odessa and Petersburgh } pound	.9019
Bremen.............pound	1.098	Port-au-Prince and Port Louis } livre poids de marc.	1.08
Buenos Ayres, Cadiz, Lima, Malaga, Valparaiso, and Vera Cruz.... } pound	1.015	Riga ....pound	.9217
Calcutta...............seer	2.053	Rio de Janeiro ....aragal	1.01
Canton & Manilla..catty	1.383	Rotterdam ....pound	2.204
Cape Town........pound	1.09	Smyrna ....oke	2.82
Constantinople ....oke	2.823	Stockholm } commercial pound....	.9375
Dantzic & Memel..pound	1.033	,, iron weight	.75
		Trieste............pound	1.236
		Venice........peso grosso	1.0518
		,, peso sottile	.6643

NOTE.—America, the British West Indies, Gibraltar, and Van Dieman's Land use the pound Avoirdupois, as in England.

EXAMPLE 1.—Suppose I purchase an article in London which weighs 50 lbs. Avoirdupois, what will it weigh in Amsterdam according to their new weight?

$50 \div 2.207 = 22.606$ or 22 lbs. 9 oz. 11.137 dr. Avoirdupois.

Ex 2.—An article that weighs 60 lbs. in Leghorn, according to their weight, what will it weigh in lbs. Avoirdupois?

$,764 \times 60 = 45.84$ lbs. Avoirdupois nearly.

LONG MEASURE.

		Fr. Metres.
12 Inches	= 1 Foot .... =	.3048
3 Feet	= 1 Yard .... =	.9144
6 Feet	= 1 Fathom ...... =	1.8288
5½ Yards	= 1 Pole or rod... =	5.0291
40 Poles	= 1 Furlong...... =	201.1632
8 Furlongs or 1760 yards ...	= 1 Mile .... =	1609.3059
3 Miles	= 1 League .... =	4827.9179

Surveying Chain = 22 yards, consists of 100 links, and each link = 7.92 inches.

FRENCH LONG MEASURE.—DECIMAL SYSTEM.

French.		English.	
1 Millimetre	=	.03937	inches.
1 Centimetre	=	.39371	„
1 Decimetre	=	3.93710	„
1 Metre	=	39.37100	„
1 Decametre	=	32.80916	feet.
1 Hectometre	=	328.09167	„
1 Kilometre	=	1093.63890	yards.
1 Myriametre	=	10936.38900	„

SYSTEME USUEL.

Usuel.		Metrical.	English.
1 Ligne...... =	2.31	Millimetres...... =	.091 inches.
1 Pouce ..... =	2.77	Centimetres...... =	1.090 „
1 Pied .... =	3.33	Decimetres ...... =	13.110 „
1 Aune...... =	12.	Decimetres ...... =	3 feet 11.24 inches.
1 Toise...... =	2.	Metres .... =	6 feet 6.74 inches.

THE LINEAL FOOT OF VARIOUS COUNTRIES, GIVEN IN ENGLISH INCHES.

	Inches.		Inches.
Amsterdam and Antwerp	= 11.143	Canton	= 12.65
Bahia, Lisbon, and Rio de Janeiro	= 12.944	Dantzic and Memel	= 11.3
Bergen, Copenhagen, Cape Town, Christiana, and Hamburgh	= 12.36	Port-au-Prince and Port Louis......	= 12.8
		Riga	= 10.79
		Stockholm	= 11.684
		Venice	= 13.68

NOTE.—The English foot is used generally throughout America, the British West Indies, Russia, and Van Dieman's Land.

LENGTH OF A MILE IN DIFFERENT COUNTRIES, GIVEN IN ENGLISH YARDS.

	Yards.		Yards.
Dantzic	8474	Poland	8239
Denmark	8244	Portugal	6760
Flanders	6864	Prussia	8237
Germany	6859	Russia	1167
Hanover	1155	Scotland	1984
Holland	8239	Spain	4634
Hungary	9113	Sweden	1170
Ireland	2240	Switzerland	9153
Netherlands	1093	Tuscany	1808

SUPERFICIAL MEASURE.

				Fr. Sq. Metres.
144	Square inches	=	1 Sq. foot	= .0929
9	Square feet	=	1 Sq. yard	= .8361
30¼	Square yards	=	1 Sq. pole	= 25.2916
40	Square poles	=	1 Rood	= 1011.6662
4	Roods or 4840 Sq. yards	=	1 Acre	= 4046.6648

A Scotch Acre contains 6084 square yards.
And an Irish Acre contains 7840 square yards.

FRENCH SUPERFICIAL MEASURES.

1 Centiare	=	1.1960	Square yards.
1 Arc (a square decametre)	=	119.6046	,,
1 Decare	=	1196.0460	,,
1 Hectare	=	11960.4604	,,
		or 2 acres, 1 rood, 35 perches.	

SOLID MEASURE.

				Fr. Cubic Metres.
1728	Cubic inches	=	1 Cubic foot	= .0283
27	Cubic feet	=	1 Cubic yard	= .7645
42	Cubic feet	=	1 Ton of Shipping	= 1.1892

A Load of unhewn timber	=	40	Cubic feet.
,, squared do	=	50	,,
,, 1 inch plank	=	600	Square feet.
,, 1½ inch do.	=	400	,,
,, 2 inch do.	=	300	,,

NUMBER OF CUBIC FEET IN A TON OF VARIOUS BODIES.

Names of Bodies.	Cubic feet in a ton.	Names of Bodies.	Cubic feet in a ton.
Marble	13.07	Beech	50.5
Granite	13.5	Teak	43
Common Stone...	14.22	Span. Mahogany.	42
Paving do.	14.83	Honduras do......	64
Sand	23.5	Maple & Riga Fir	47.8
Coal	28.7	Larch	65.8
Tallow	38	Pitch Pine	53.6
English Oak	37	Oil	39
American do	41	Proof Spirits	38.6
Ash	47	Distilled Water...	35.8
Elm	64.5	Sea do......	34.7

A Gallon of Oil weighs	....	9.32 lbs.	Avoirdupois.
„	Distilled Water	10	„
„	Sea Water	10.32	„
„	Proof Spirits	9.3	„

IMPERIAL WINE MEASURE.

		1 Gill	=	8.665	cubic inches.
4 Gills	=	1 Pint	=	34.659	„
2 Pints	=	1 Quart	=	69.318	„
4 Quarts	=	1 Gallon	=	277.274	„
10 Gallons......	=	1 Anker	=	1.604	cubic feet.
18 Gallons......	=	1 Runlet	=	2.888	„
42 Gallons......	=	1 Tierce..........	=	6.739	„
63 Gallons......	=	1 Hogshead.....	=	10.109	„
84 Gallons......	=	1 Puncheon.....	=	3.478	„
126 Gallons......	=	1 Pipe	=	20.218	„
252 Gallons......	=	1 Tun	=	40.435	„

FRENCH MEASURES OF CAPACITY.

1 Millitre	=	.06103	cubic inches.
1 Centilitre	=	.61028	„
1 Decilitre.............................	=	6.10280	„
1 Litre (a cubic decimitre).......	=	61.02803	„
1 Decalitre...........	=	610.28028	„
1 Hectolitre	=	3.5317	cubic feet.
1 Kilolitre.............................	=	35.3171	„
1 Myrialitre....	=	353.17146	„
The Litron usuel.......	=	62.45	cubic inches.

A TABLE

Showing the relative value between the British Imperial Gallon and Foreign measures of capacity.

Places and names of measures.	Imp. Galls.	Places and names of measures.	Imp. Galls
Amsterdam...mingle	.266	Havannah ......arroba	3.415
„ ......kan	.220	Leghorn...wine fiasco	.499
Antwerp......stoopen	.608	„ ...oil fiasco	.443
„ ....litre	.220	Lisbon .. ....almude	3.641
Barcelona.....cortane	2.270	Malta............caffiso	4.582
Bordeaux.........velte	1.672	Mocha ....cuda	1.666
Cadiz....great arroba	3.540	Naples...wine barilla	9.164
„ ...small arroba	3.124	„ ....oil staja	2.226
Constantinople..alma	1.146	Oporto.........almude	5.311
Dantzic...beer anker	12.925	Petersburgh ..wedro	2.707
„ ...wine anker	9.915	Rotterdam ... ..stoop	.564
Genoa ...wine barilla	16.349	Stockholm......kanne	.575
„ ...oil barilla	14.162	Trieste.........boccali	.312
Gibraltar ....gallon	.909	Venice....wine sechii	2.377
Hamburg.....stubjen	.797	„ ....oil miro	3.356

NOTE.—America, the British West Indies, and Van Dieman's Land, use the same measures of capacity as in England.

IMPERIAL ALE AND BEER MEASURE.

		1 Gill	=	8.665	cubic inches.
4 Gills	=	1 Pint............	=	34.659	„
2 Pints.........	=	1 Quart	=	69.318	„
4 Quarts	=	1 Gallon	=	277.274	„
9 Gallons... ..	=	1 Firkin.........	=	1.444	cubic feet.
18 Gallons......	=	1 Kilderkin	=	2.888	„
36 Gallons......	=	1 Barrel	=	5.776	„
54 Gallons......	=	1 Hogshead....	=	8.664	„
72 Gallons......	=	1 Puncheon	=	11.553	„
108 Gallons......	=	1 Butt............	=	17.329	„

NOTE.—The old Ale Gallon contained 282 cubic inches, and the old Wine Gallon contained 231, hence

Imperial Gallons.........	× .98324	=	old Ale Gallons.
Imperial Gallons.........	× 1.20032	=	old Wine Gallons.
Old Ale Gallons	× 1.01704	=	Imperial Gallons.
Old Wine Gallons	× .83311	=	Imperial Gallons.
Cubic feet	× 6.232	=	Imperial Gallons.
Cubic inches	× .003607	=	Imperial Gallons.

IMPERIAL DRY MEASURE.

	1 Gill	=	8.665 cubic inches.
4 Gills	= 1 Pint	=	34.659 „
2 Pints	= 1 Quart	=	69.318 „
4 Quarts	= 1 Gallon	=	277.274 „
2 Gallons	= 1 Peck	=	554.548 „
4 Pecks	= 1 Bushel	=	1.2837 cubic feet.
8 Bushels	= 1 Quarter	=	10.2694 „
32 Bushels	= 1 Chaldron	=	41.0784 „
40 Bushels	= 1 Way	=	51.3480 „
80 Bushels	= 1 Last	=	102.6960 „

NOTE.—The Winchester bushel contained 2150.42 cubic inches, and the Imperial bushel contains 2218.192 cubic inches,—hence,
Imperial bushels.........× 1.0315157 = Winchester bushels,
and Winchester bushels....× .969447 = Imperial bushels.

A bushel of wheat is reckoned	= 60	lbs. Avoirdupois.
„ barley	= 47	„
„ oats	= 38	„
„ pease	= 64	„
„ beans	= 63	„

IMPERIAL MEASURE OF CAPACITY FOR COALS, CULM, LIME, FISH, POTATOES, FRUIT, AND OTHER GOODS.

The Gallon...... = 351.9375 cubic inches.

2 Gallons	= 1 Peck	=	703.875 cubic inches.
4 Pecks	= 1 Bushel	=	2815.5
3 Bushels	= 1 Sack	=	4.888 cubic feet nearly.
12 Sacks	= 1 Chaldron	=	58.656

DIMENSIONS OF DRAWING PAPER IN FEET AND INCHES.

Wove Antiquarian	4 feet	4 inches	by	2 feet	7 inches.
Double Elephant	3 „	4 „	by	2 „	2 „
Atlas	2 „	9 „	by	2 „	2 „
Columbier	2 „	9¾ „	by	1 „	11 „
Elephant	2 „	3¾ „	by	1 „	10¼ „
Imperial	2 „	5 „	by	1 „	9¼ „
Super royal	2 „	3 „	by	1 „	7 „
Royal	2 „	0 „	by	1 „	7 „
Medium	1 „	10 „	by	1 „	6 „
Demy	1 „	7½ „	by	1 „	3¼ „

DIMENSIONS OF IMPERIAL CONICAL LIQUID MEASURES.

Diameters.

Two Gallon...	Top $2\frac{1}{2}$ in...	Bottom $11\frac{1}{2}$ in...	Depth	12.66498 in.
Gallon	„ 2	„ 9	„	10.28498
Half Gallon ...	„ $1\frac{3}{4}$	„ 7	„	8.23415
Quart	„ $1\frac{1}{4}$	„ $5\frac{3}{4}$	„	6.33249
Pint	„ 1	„ $4\frac{1}{2}$	„	5.14249
Half Pint	„ $\frac{7}{8}$	„ $3\frac{1}{2}$	„	4.11708
Gill..............	„ $\frac{5}{8}$	„ $2\frac{7}{8}$	„	3.16625

DIMENSIONS OF IMPERIAL CYLINDRICAL DRY MEASURES.

Diameters and Depths.

Eighth of a Peck.........	a cylinder of	4.45232 inches.
Forpit or Half Gallon..	„	5.60957
Gallon or Half Peck....	„	7.06762
Peck........................	„	8.90464
Half Bushel	„	11.21914
Bushel......................	„	14.13524
Quarter.....................	„	28.27048

NOTE.—Multiply the decimal by 8, the product equal inches and parts of an inch.

DECIMAL FRACTIONS.

A Decimal Fraction derives its name from the Latin, *decem*, "ten," which denotes the nature of its numbers, representing the parts of an integral quantity, divided into a tenfold proportion.

NUMERATION

Teacheth to read or write any number proposed, either by words or characters.

In Decimal Fractions, the integer, or whole thing, as a gallon, a pound, a yard, &c., is supposed to be divided into ten equal parts, called tenths; those tenths into ten equal parts, called hundredths; and those hun-

dredths into ten equal parts, called thousandths; and so on, without end. So that the denominator of a decimal being always known to consist of a unit, with as many ciphers as the numerator has places, is, therefore, never expressed, being understood to be 10, 100, 1000, 10,000, &c., according as the numerator consists of 1, 2, 3, 4, or more figures; thus, instead of $\frac{2}{10}$, $\frac{24}{100}$, $\frac{211}{1000}$, the numerators only are written with a dot or comma before them, thus, .2, .24, .211.

If a unit or whole quantity of any description, as a gallon, a pound, a foot, &c., be divided into ten equal parts, the decimal represents as many of those parts as the decimal figure expresses,—thus, .7 means seven of those parts, or seven-tenths; but if the decimal consisted of two figures, unity would be understood to be divided into a hundred equal parts, of which the decimal represents as many as the figure expresses,—thus .65 means sixty-five of those parts, or sixty-five hundredths; and if the decimal consisted of three figures, unity would be supposed to be divided into a thousand equal parts, of which the decimal represents as many as the number expresses,—thus .625 is six hundred and twenty-five of those parts; or, suppose the decimal .0625, unity would be understood to be divided into 10,000 equal parts; but the value of decimal figures is made more plain by means of the following

TABLE.

Tenths	.5
Hundredths	.56
Thousandths	.567
Ten thousandths	.5678
Hundred thousandths, &c....	.56789

Thus, .5 is read five-tenths; .56 is read five-tenths and six-hundredths, or fifty-six hundredths; .567 is read five-tenths, six-hundredths, and seven-thousandths, or five hundred and sixty-seven thousandths; and so on, as in the table.

Ciphers to the right hand of decimals cause no difference in their value; for .5, .50, .500 are decimals of the same value, being each equal to $\frac{1}{2}$; that is, $.5 = \frac{5}{10}$, $.50 = \frac{50}{100}$, $.500 = \frac{500}{1000}$. But if ciphers are placed on the left hand of decimals, they diminish their value in a tenfold proportion; thus, .3, .03, .003, are three-tenths, three-hundredths, and three-thousandths, and answer to the vulgar fractions $\frac{3}{10}$, $\frac{3}{100}$, $\frac{3}{1000}$, respectively.

A whole number and decimal are thus expressed, 85.75, 85.04, &c.

REDUCTION OF DECIMALS.

By reduction we change vulgar fractions, and the lesser parts of coin, weight, measure, &c., into decimals, and find the value of any decimal given.

Because decimals increase their value towards the left hand, and decrease their value towards the right hand, in the same tenfold proportion with integers, or whole numbers, they may be annexed to whole numbers, and worked in all respects as whole numbers; hence, if simple arithmetic be well understood, there is little more to be learned than the placing of the separating point—the rule for which ought to be well attended to.

1.—*To reduce a vulgar fraction to a decimal of an equal value.*

Rule.—Add a cipher, or ciphers, to the numerator, and divide by the denominator, the quotient will be the decimal required.

EXAMPLE.—Reduce $\frac{14}{32}$ to a decimal.

```
32)14.0000(.4375
   128
   ---
    120
     96
    ---
    240
    224
    ---
     160
     160
     ===
```

Thus you may take any number of ciphers at pleasure, but their number will be best ascertained when the work is finished; then you must have as many decimal figures as you have taken annexed ciphers in dividing; and if there are not so many in the quotient, you must prefix ciphers to the left hand of it,—thus, $\frac{1.00000}{32} = .03125$.

Sometimes the quotient figures will repeat continually, as $\frac{2}{3}$, thus, $\frac{2.000}{3} = .66\dot{6}$, then it is called a repetend, and the last figure may be dashed or marked, to distinguish it from a terminate decimal.

Sometimes two, three, or more figures will repeat, as $\frac{12}{33}$, thus, $\frac{12.0000}{33} = .\dot{3}63\dot{6}$; such are called compound repetends or circulates, and the first and last figure may be dashed or marked.

2.—*To reduce the lesser parts of coin, weights, measures, &c., to decimals.*

RULE.—Divide the least name by such number as will reduce it to the next greater; to the decimal so obtained prefix the given number of the same name, then divide by such number as will reduce it to the next greater, always annexing ciphers to the dividend, as occasion may require: thus proceed till it be reduced to the decimal of the required integer. Or, reduce the given parts to a simple quantity, by reducing them to the lowest name mentioned; annex ciphers thereto, and divide by such numbers as will reduce them to the name required. Or, reduce the given parts to a vulgar fraction, and that fraction to a decimal.

EXAMPLE 1.—Reduce 17s. 10½d. to the decimal of a pound sterling.

$\frac{1}{2}0 = .5 + 10d. = \frac{10.500}{12} = .875 + 17s. = \frac{17.87500}{20} = .89375$, the decimal required.

EXAMPLE 2.—Reduce 2 feet 9 inches to the decimal of a yard.

Vulgar fraction $\frac{33}{36}$, and $\frac{33.0000}{36} = .9166$ as required.

To find the value of any given decimal.

RULE.—Multiply the decimal given by the number of parts of the next inferior denomination, cutting off the decimals from the product; then multiply the remainder by the next inferior denomination; thus proceeding till you have brought the least known parts of the integer.

EXAMPLE 1.—Required the value of .89375 of a pound sterling.

$$\begin{array}{r} .89375 \\ 20 \\ \hline 17.87500 \\ 12 \\ \hline 10.50000 \\ 2 \\ \hline 1.00000 \end{array}$$ or, 17s. 10½d.

EXAMPLE 2.—Reduce .625 of a hundred weight to its proper terms.

$.625 \times 4 = 2.500 \times 28 = 14.000$, or 2 quarters and 14 lbs.

A TABLE

Of Reciprocals, for obtaining Decimal Equivalents.

No.	Recip.	No.	Recip.	No.	Recip.	No	Recip.	No.	Recip.
1	1.000000	51	.019607	101	.009900	151	.006623	201	.004975
2	.500000	52	.019231	102	.009803	152	.006579	202	.004951
3	.333333	53	.018868	103	.009709	153	.006536	203	.004927
4	.250000	54	.018519	104	.009616	154	.006494	204	.004901
5	.200000	55	.018182	105	.009523	155	.006451	205	.004879
6	.166667	56	.017857	106	.009433	156	.006411	206	.004855
7	.142857	57	.017543	107	.009345	157	.006370	207	.004831
8	.125000	58	.017242	108	.009260	158	.006329	208	.004807
9	.111111	59	.016949	109	.009174	159	.006290	209	.004785
10	.100000	60	.016667	110	.009091	160	.006250	210	.004762
11	.090901	61	.016393	111	.009010	161	.006211	211	.004740
12	.083333	62	.016129	112	.008928	162	.006172	212	.004716
13	.076923	63	.015873	113	.008850	163	.006135	213	.004695
14	.071428	64	.015625	114	.008771	164	.006097	214	.004673
15	.066667	65	.015385	115	.008695	165	.006061	215	.004651
16	.062500	66	.015151	116	.008620	166	.006025	216	.004629
17	.058823	67	.014925	117	.008548	167	.005988	217	.004609
18	.055556	68	.014705	118	.008475	168	.005952	218	.004588
19	.052632	69	.014492	119	.008403	169	.005917	219	.004566
20	.050000	70	.014285	120	.008333	170	.005882	220	.004546
21	.047620	71	.014085	121	.008264	171	.005847	221	.004525
22	.045455	72	.013889	122	.008196	172	.005813	222	.004505
23	.043078	73	.013698	123	.008130	173	.005781	223	.004485
24	.041667	74	.013513	124	.008065	174	.005748	224	.004465
25	.040000	75	.013333	125	.008000	175	.005715	225	.004444
26	.038462	76	.013158	126	.007936	176	.005682	226	.004425
27	.037038	77	.012987	127	.007875	177	.005650	227	.004406
28	.035715	78	.012820	128	.007812	178	.005618	228	.004386
29	.034483	79	.012659	129	.007752	179	.005586	229	.004366
30	.033333	80	.012500	130	.007693	180	.005556	230	.004348
31	.032259	81	.012346	131	.007634	181	.005524	231	.004329
32	.031250	82	.012195	132	.007576	182	.005495	232	.004311
33	.030303	83	.012048	133	.007519	183	.005464	233	.004292
34	.029412	84	.011904	134	.007463	184	.005434	234	.004273
35	.028572	85	.011765	135	.007408	185	.005406	235	.004256
36	.027778	86	.011628	136	.007352	186	.005376	236	.004238
37	.027028	87	.011494	137	.007299	187	.005347	237	.004220
38	.026316	88	.011364	138	.007247	188	.005320	238	.004201
39	.025642	89	.011235	139	.007195	189	.005292	239	.004184
40	.025000	90	.011111	140	.007143	190	.005264	240	.004167
41	.024390	91	.010989	141	.007093	191	.005235	241	.004150
42	.023809	92	.010870	142	.007042	192	.005208	242	.004132
43	.023255	93	.010753	143	.006994	193	.005182	243	.004116
44	.022727	94	.010639	144	.006944	194	.005155	244	.004098
45	.022222	95	.010527	145	.006896	195	.005129	245	.004081
46	.021739	96	.010417	146	.006850	196	.005102	246	.004065
47	.021276	97	.010310	147	.006802	197	.005076	247	.004048
48	.020833	98	.010204	148	.006756	198	.005051	248	.004033
49	.020408	99	.010101	149	.006712	199	.005026	249	.004016
50	.020000	100	.010000	150	.006667	200	.005000	250	.004000

The numbers in the table are the denominators of the fraction: hence, multiply the reciprocal of the denominator by the numerator of the fraction, and the product is the decimal equivalent.

Thus, suppose the decimal equivalent of 7-16ths be required :—
Reciprocal of 16 = .0625 × 7 = .4375 its decimal equivalent.

ADDITION OF DECIMALS.

RULE.—Arrange the numbers under each other, according to their several values; find the sum, as in addition of whole numbers, and cut off for decimals as many figures to the right hand as there are decimals in any one of the given numbers.

EXAMPLE.—What is the sum of 23.45, 7.849, 543.2, 8.6234, 253.004?

```
 23.45
  7.849
543.2
  8.6234
253.004
--------
836.1264
```

If any of the decimals be repetends, continue them beyond the others, and make them end together; then, in adding, increase the sum of the first column by as many units as there are nines therein; as,

```
.75
.6666
.8888
.875
.4444
------
3.6250
```

Here the first sum, 18, contains two nines; therefore two added to 18 = 20. The rest of the work is the same as usual in others; the repetend is 0, so the sum is finite.

If some of the decimals be repetends, and others circulates, continue them both beyond those that are finite, and till their periods end together; then to the sum of the first column add as many as would arise to carry to it if they were continued farther; so will you have a circulate in the sum. Thus,

```
 2.5
 3.6066666
 7.6969696
14.3723723
----------
28.236008
```

The repetend of $.\dot{6}$, the circulate of $\dot{6}\dot{9}$ and .372, continued till their periods end together. It may easily be observed that there would be one to carry to the first column if it were carried any farther.

NOTE.—It is not always necessary to attend to the rule for repetends and circulates; three or four decimal figures, according to the rule, being sufficiently near the truth for common calculations.

SUBTRACTION OF DECIMALS.

RULE.—Place the numbers directly under each other according to their several values, subtract as in whole numbers, and cut off for decimals, as in addition.

EXAMPLE.—Subtract 35.87043 from 132.005.

```
132.005 + 10
 35.87043
---------
 96.13457
```

If both be single repetends, make them end together; and if there be occasion to borrow at the first figure, borrow 9 only instead of 10;

thus,—$.833\dot{3}+9$

```
.6666
-----
.1666
```

If both be circulates, or one a repetend and the other a circulate, continue both till their periods end together; then if there should be occasion to borrow at the following figure, were they continued that figure farther, carry one to the first figure; and if the numbers be in different denominations, reduce them till they be alike.

Subtract $\frac{834}{999}$ from $1\frac{2}{3}$; thus,

```
1.666666
 .834834 + 1
 --------
 .831831
```

MULTIPLICATION OF DECIMALS.

RULE.—Place the factors under each other, and multiply them together, as in whole numbers; then point off as many figures from the product *(counting from right to left)* as there are decimal places in both factors; observing, if there be not enough, to annex as many ciphers to the left hand of the product as will supply the deficiency.

EXAMPLE.—Multiply .4375 by .125.

```
   .4375
    .125
--------
   21875
   8750
  4375
--------
.0546875
```

Here the product of .4375 by .125 is .0546875; but as there are three places of decimals in the multiplier, and four in the multiplicand, a cipher must be added on the left hand of the product to reduce it to its proper terms.

To multiply a repetend by a single figure, add 1 to the first product for every 9 therein, so will you have a repetend in the product; and if there be several figures in the multiplier, do so with each product, and continue them till they end together; then add them as so many repetends.

If the multiplicand be a circulate, consider the increase that would arise to the first product if the multiplicand were continued farther: thus do with each product, make them end together, and add them by the rule for adding circulates.

To contract the operation so as to retain only as many decimals in the product as may be thought necessary.

Rule.—Place the unit figure of the multiplier under that figure of the multiplicand whose place is the last to be retained in the product, and dispose of the rest so that they may all stand in contrary order to that in which they are usually placed.

Then, in multiplying, reject all the figures to the right hand of the multiplying digit, and set down the product so that the right hand figures may fall in a straight line under each other; observing to increase the first figure of every line with what would arise, by carrying 1 from 5 to 14,—2 from 15 to 24,—3 from 25 to 34, &c., from the product of the two preceding figures when you begin to multiply; and the sum will be the product required.

Example.—Multiply 27.14986 by 92.41035.

Common way.

27.14	986
92.41	035
13	574930
81	44958
2714	9860
108599	44
542997	2
24434874	
2508.9280	650510

Contracted way.

27.14986
53014.29
24434874
542997
108599
2715
81
14
2508.9280

DIVISION OF DECIMALS.

RULE.—Prepare your decimals as directed for multiplication, divide as in whole numbers, cut off as many figures for decimals in the quotient as the number in the dividend exceeds the number in the divisor, namely, make the number of decimal figures in the divisor and quotient together equal to the number in the dividend.

EXAMPLE.—Divide 173.5425 by 3.75.

```
3.75)173.5425(46.278
     1500
     ----
      2354
      2250
      ----
       1042
        750
       ----
        2925
        2625
        ----
         3000
         3000
```

Although you may take additional ciphers at pleasure, care must be had in reckoning the number taken in dividing for decimals in the dividend; and if you put the decimal point in the quotient at any part of the operation, continuing the operation afterwards will not cause the point to be removed.

If there should not be so many figures in the quotient as there should be decimals, prefix ciphers on the left hand to make up the number.

EXAMPLE.—Divide 1.4850 by 247.5.

Thus, $\frac{1.4850}{247.5} = .006$. And if there be not as many decimal figures in the dividend as in the divisor, you may annex a sufficient number of ciphers; and if there be not a remainder, you must add ciphers to the right hand of the quotient till you have taken as many in the dividend as will make the decimal figures therein equal to those in the divisor: thus,—

$$\frac{14856}{2.476} = 6000.$$

A TABLE

Of the fractional parts of an inch when divided into thirty-two parts: likewise a foot of twelve inches reduced to decimals.

Parts.	*Decimals.*	*Parts.*	*Decimals.*	*Parts of a foot.*	*Decimals.*
$\frac{7}{8}$ & $\frac{3}{32}$	= .96875	$\frac{3}{8}$ & $\frac{3}{32}$	= .46875	11	= .9166
$\frac{7}{8}$ & $\frac{1}{16}$	= .9375	$\frac{3}{8}$ & $\frac{1}{16}$	= .4375	10	= .8333
$\frac{7}{8}$ & $\frac{1}{32}$	= .90625	$\frac{3}{8}$ & $\frac{1}{32}$	= .40625	9	= .75
$\frac{7}{8}$	= .875	$\frac{3}{8}$	= .375	8	= .6666
$\frac{3}{4}$ & $\frac{3}{32}$	= .84375	$\frac{1}{4}$ & $\frac{3}{32}$	= .34375	7	= .5833
$\frac{3}{4}$ & $\frac{1}{16}$	= .8125	$\frac{1}{4}$ & $\frac{1}{16}$	= .3125	6	= .5
$\frac{3}{4}$ & $\frac{1}{32}$	= .78125	$\frac{1}{4}$ & $\frac{1}{32}$	= .28125	5	= .4166
$\frac{3}{4}$	= .75	$\frac{1}{4}$	= .25	4	= .3333
$\frac{5}{8}$ & $\frac{3}{32}$	= .71875	$\frac{1}{8}$ & $\frac{3}{32}$	= .21875	3	= .25
$\frac{5}{8}$ & $\frac{1}{16}$	= .6875	$\frac{1}{8}$ & $\frac{1}{16}$	= .1875	2	= .1666
$\frac{5}{8}$ & $\frac{1}{32}$	= .65625	$\frac{1}{8}$ & $\frac{1}{32}$	= .15625	1	= .0833
$\frac{5}{8}$	= .625	$\frac{1}{8}$	= .125	$\frac{7}{8}$	= .07291
$\frac{1}{2}$ & $\frac{3}{32}$	= .59375	$\frac{3}{32}$	= .09375	$\frac{3}{4}$	= .0625
$\frac{1}{2}$ & $\frac{1}{16}$	= .5625	$\frac{1}{16}$	= .0625	$\frac{5}{8}$	= .0528
$\frac{1}{2}$ & $\frac{1}{32}$	= .53125	$\frac{1}{32}$	= .03125	$\frac{1}{2}$	= .04166
$\frac{1}{2}$	= .5			$\frac{3}{8}$	= .03125
				$\frac{1}{4}$	= .02083
				$\frac{1}{8}$	= .01041

The utility of this table will appear evident by means of the following example:

Suppose a board, or plate, to be $30\frac{1}{4}$ inches long, $8\frac{5}{8}$ inches broad, and $\frac{3}{8}$ and $\frac{1}{16}$ of an inch in thickness; required its content in cubic inches.

$30.25 \times 8.625 = 260.90625 \times .4375 = 114.146$, &c. cubic inches.

OF THE SQUARE ROOT.

When a number is multiplied by itself, as 6 × 6, or 9 × 9, &c., it produces the square or second power of that number; and the number itself is called the root of that square.

A root consisting of a single figure is found by inspection of the following table:—

Root	1	2	3	4	5	6	7	8	9
Squares	1	4	9	16	25	36	49	64	81
Cubes	1	8	27	64	125	216	343	512	729

To extract or find the square root of any number which consists of more figures than one.

Rule.—Make a point or dot over every second figure, commencing at the right hand, by which the given square will be pointed into periods of two figures each, except the first or left-hand period, which will sometimes have but one.

The unit figure must always be the latter figure in the period; for the decimal point must be between the periods, and not in the middle of a period.

Find the greatest root in the first period, which write in the quotient or root, and the square thereof under the same period; subtract therefrom, and to the remainder annex the next period for a dividend.

Double the quotient for a divisor; see how often the divisor is contained in the dividend, with this consideration, that the answer must be the unit's figure of the divisor.

Write the answer in the quotient, also in the unit place of the divisor; then multiply the divisor, so completed, by the last quotient figure; write the product under the dividend, and subtract therefrom; to the remainder annex the next period for a new dividend.

Thus proceed with every period; and if there be still a remainder, annex pairs of ciphers for additional periods, till you have a competent number of decimals in the root.

Vulgar fractions, &c., may be reduced to decimals.

The periods which are whole numbers give whole numbers, and decimal periods give decimals in the root.

EXAMPLE 1.—What is the square root of 76176?

76176(276, or 276 × 276 = 76176.
4

47)361
329

546)3276
3276

EXAMPLE 2.—Required the root of .75.

.75(.866 or $.866^2$ + 44 = .75
64

166)1100
966

1726)10400
10356

44

EXAMPLE 3.—Required the root of .00854.

.00854(.029 or	.029
4	.29
49)454	261
441	58
13	841
	+ 13
	.00854

OF THE CUBE ROOT.

When a square is multiplied again by its root, as $6 \times 6 \times 6$, it produces the cube or third power of that root.

Single cubes are found by inspection of the preceding table.

To extract the root of any number that consists of more than one figure.

Rule.—Point the given cube into periods of three figures, and so that the unit figure be the last in its period; then from the first period subtract the greatest cube it contains; put the root as a quotient, and to the remainder bring down the next period for a dividend.

Find a divisor by multiplying the square of the root by 300; see how often it is contained in the dividend; and the answer gives the next figure in the root.

Multiply the divisor by the last figure in the root. Multiply all the figures in the root by 30, except the last; and that product by the square of the last. Cube the last figure in the root; add these three last found numbers together, and subtract this sum from the dividend; to the remainder bring down the next period for a new dividend, and proceed as before.

Example.—Required the cube root of 444194947.

$$
\begin{array}{rl}
 & 44\dot{4}19\dot{4}94\dot{7}(763 \\
 & \underline{343} \\
7 \times 7 \times 300 = 14700) & 101194 \\
 & \underline{95976} \\
76 \times 76 \times 300 = 1732800) & 5218947 \\
 & \underline{5218947}
\end{array}
$$

$$
\begin{array}{lr}
\text{1. Divisor} & 14700 \\
 & \underline{6} \\
 & 88200 \\
7 \times 30 \times 36 = & 7560 \\
6 \times 6 \times 6 = & \underline{216} \\
 & 95976
\end{array}
\qquad
\begin{array}{lr}
\text{2. Divisor} & 1732800 \\
 & \underline{3} \\
 & 5198400 \\
76 \times 30 \times 9 = & 20520 \\
3 \times 3 \times 3 = & \underline{27} \\
 & 5218947
\end{array}
$$

Involution and Evolution of numbers are very conveniently performed upon the ***Engineer's Slide Rule***, for when the slide is set straight at both ends, C is a line of squares, and D a line of roots; consequently, against any number upon D is its square upon C, and against any number upon C is its root upon D.

EXAMPLE 1.—What is the square of 16?

Opposite 16 upon D is 256, the square number upon C.

EXAMPLE 2.—Required the square root of 625.

Opposite 625 upon C is 25 upon D, the root required.

The cube root is performed by inverting the slide, and setting the number to be cubed upon B to the same number upon D, and against 1 or 10 upon D is the cube number upon B. Also, set the cube number upon B to 1 or 10 upon D, and where two numbers of equal value meet upon the lines B and D is the root required.

EXAMPLE 1.—Required the cube of 9.

Set 9 upon B to 9 upon D, and against 10 upon D is 729 upon B.

EXAMPLE 2.—Required the cube root of 343.

Set 343 upon B to 10 upon D, and against 7 upon B is 7 upon D, the root required.

These lines also serve to multiply the square of any number, any number of times: thus,—

To find the product of 6 times 6, multiplied by 3.

Set 3 upon B to 6 upon D, and against 10 upon D, is 108 upon B.

A TABLE

***Containing the square and cube roots of all numbers from* 1 *to* 1728.**

Numb.	*Square Roots.*	*Cube Roots.*	*Numb.*	*Square Roots.*	*Cube Roots*
1	1.0000	1.0000	46	6.7823	3.5830
2	1.4142	1.2599	47	6 8556	3.6088
3	1.7320	1.4422	48	6.9282	3.6342
4	2.0000	1.5874	49	7.0000	3.6593
5	2.2360	1.7099	50	7.0710	3.6840
6	2.4494	1.8171	51	7.1414	3.7084
7	2.6457	1.9129	52	7.2111	3.7325
8	2.8284	2.0000	53	7.2801	3.7562
9	3.0000	2.0800	54	7.3484	3.7797
10	3.1622	2.1544	55	7.4161	3.8029
11	3.3166	2.2239	56	7.4833	3.8258
12	3.4641	2.2894	57	7.5498	3.8485
13	3.6055	2 3513	58	7.6157	3.8708
14	3.7416	2.4101	59	7 6811	3.8929
15	3.8729	2.4662	60	7.7459	3.9148
16	4.0000	2.5198	61	7.8102	3.9364
17	4.1231	2.5712	62	7.8740	3.9578
18	4.2426	2.6207	63	7.9372	3.9790
19	4.3588	2.6684	64	8.0000	4.0000
20	4.4721	2.7144	65	8.0622	4.0207
21	4.5825	2.7589	66	8.1240	4.0412
22	4.6904	2.8020	67	8.1853	4.0615
23	4.7958	2.8438	68	8.2462	4.0816
24	4.8989	2.8844	69	8.3066	4.1015
25	5.0000	2.9240	70	8.3666	4.1212
26	5.0990	2.9624	71	8.4261	4.1408
27	5.1961	3.0000	72	8.4852	4.1601
28	5.2915	3.0365	73	8.5440	4.1793
29	5.3851	3.0723	74	8.6023	4.1983
30	5.4772	3.1072	75	8.6602	4.2171
31	5.5677	3.1413	76	8.7177	4.2358
32	5.6568	3.1748	77	8.7749	4.2543
33	5.7445	3.2075	78	8.8317	4.2726
34	5.8309	3.2396	79	8.8881	4.2908
35	5.9160	3.2710	80	8.9442	4.3088
36	6.0000	3.3019	81	9.0000	4.3267
37	6.0827	3.3322	82	9.0553	4.3444
38	6.1644	3.3619	83	9.1104	4.3620
39	6.2449	3.3912	84	9.1651	4.3795
40	6.3245	3.4199	85	9.2195	4.3968
41	6.4031	3.4482	86	9.2736	4.4140
42	6.4807	3.4760	87	9.3273	4.4310
43	6.5574	3.5033	88	9.3808	4.4479
44	6.6332	3.5303	89	9.4339	4.4647
45	6.7082	3.5568	90	9.4868	4.4814

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
91	9.5393	4.4979	140	11.8321	5.1924
92	9.5916	4.5143	141	11.8743	5.2048
93	9.6436	4 5306	142	11.9163	5.2171
94	9.6953	4.5468	143	11.9582	5.2293
95	9.7467	4.5629	144	12.0000	5.2414
96	9.7979	4.5788	145	12.0415	5.2535
97	9.8488	4.5947	146	12.0830	5.2656
98	9.8994	4.6104	147	12.1243	5.2776
99	9.9498	4.6260	148	12.1655	5.2895
100	10.0000	4.6415	149	12.2065	5.3014
101	10.0498	4.6570	150	12.2474	5.3132
102	10.0995	4.6723	151	12.2882	5.3250
103	10.1488	4.6875	152	12.3288	5.3368
104	10.1980	4.7026	153	12.3693	5.3484
105	10.2469	4.7176	154	12.4096	5.3601
106	10.2956	4.7326	155	12.4498	5.3716
107	10.3440	4.7474	156	12.4899	5.3832
108	10.3923	4.7622	157	12.5299	5.3946
109	10.4403	4.7768	158	12.5698	5.4061
110	10.4880	4.7914	159	12.6095	5.4175
111	10.5356	4.8058	160	12.6491	5.4288
112	10.5830	4.8202	161	12.6885	5.4401
113	10.6301	4.8345	162	12.7279	5.4513
114	10.6770	4.8488	163	12.7671	5.4625
115	10.7238	4.8629	164	12.8062	5.4737
116	10.7703	4.8769	165	12.8452	5 4848
117	10.8166	4.8909	166	12.8840	5.4958
118	10.8627	4.9048	167	12.9228	5.5068
119	10.9087	4.9186	168	12.9614	5.5178
120	10.9544	4 9324	169	13.0000	5.5287
121	11.0000	4.9460	170	13.0384	5.5396
122	11.0453	4.9596	171	13.0766	5.5504
123	11.0905	4.9731	172	13.1148	5.5612
124	11.1355	4.9866	173	13.1529	5.5720
125	11.1803	5.0000	174	13.1909	5.5827
126	11.2249	5.0132	175	13.2287	5.5934
127	11.2694	5.0265	176	13.2664	5.6040
128	11.3137	5.0396	177	13.3041	5.6146
129	11.3578	5.0527	178	13.3416	5.6252
130	11.4017	5.0657	179	13.3790	5.6357
131	11.4455	5.0787	180	13.4164	5.6462
132	11.4891	5 0916	181	13.4536	5.6566
133	11.5325	5.1044	182	13.4907	5.6670
134	11.5758	5 1172	183	13.5277	5.6774
135	11.6189	5.1299	184	13.5646	5.6877
136	11.6619	5.1425	185	13 6014	5.6980
137	11.7046	5.1551	186	13.6381	5.7082
138	11.7473	5.1676	187	13.6747	5.7184
139	11.7898	5.1801	188	13.7113	5.7286

Numb.	Square Roots.	Cube Roots	Numb.	Square Roots.	Cube Roots.
189	13.7477	5.7387	238	15.4272	6.1971
190	13.7840	5.7488	239	15.4596	6.2058
191	13.8202	5.7589	240	15.4919	6.2144
192	13.8564	5.7689	241	15.5241	6.2230
193	13.8924	5.7789	242	15.5563	6.2316
194	13.9283	5.7889	243	15.5884	6.2402
195	13.9642	5.7988	244	15.6204	6.2487
196	14.0000	5.8087	245	15.6524	6.2573
197	14.0356	5.8186	246	15.6843	6.2658
198	14.0712	5.8284	247	15.7162	6.2743
199	14.1067	5.8382	248	15.7480	6.2827
200	14.1421	5.8480	249	15.7797	6.2911
201	14.1774	5.8577	250	15.8113	6.2996
202	14.2126	5.8674	251	15.8429	6.3079
203	14.2478	5.8771	252	15.8745	6.3163
204	14.2828	5.8867	253	15.9059	6.3247
205	14.3178	5.8963	254	15.9373	6.3330
206	14.3527	5.9059	255	15 9687	6.3413
207	14.3874	5.9154	256	16.0000	6.3496
208	14.4222	5.9249	257	16.0312	6.3578
209	14.4568	5.9344	258	16.0623	6.3660
210	14.4913	5.9439	259	16.0934	6.3743
211	14.5258	5.9533	260	16.1245	6.3825
212	14.5602	5.9627	261	16.1554	6.3906
213	14.5945	5.9720	262	16.1864	6.3988
214	14.6287	5.9814	263	16.2172	6.4069
215	14.6628	5 9907	264	16.2480	6.4150
216	14.6969	6.0000	265	16.2788	6.4231
217	14.7309	6.0092	266	16.3095	6.4312
218	14.7648	6.0184	267	16.3401	6.4392
219	14.7986	6.0276	268	16.3707	6.4473
220	14.8323	6.0368	269	16.4012	6.4553
221	14.8660	6.0459	270	16.4316	6.4633
222	14.8996	6.0550	271	16.4620	6.4712
223	14.9331	6.0641	272	16.4924	6.4792
224	14.9666	6.0731	273	16.5227	6.4871
225	15.0000	6.0822	274	16.5529	6.4950
226	15.0332	6.0911	275	16.5831	6.5029
227	15.0665	6.1001	276	16.6132	6.5108
228	15.0996	6.1091	277	16.6433	6.5186
229	15.1327	6.1180	278	16.6733	6.5265
230	15.1657	6.1269	279	16.7032	6.5343
231	15.1986	6.1357	280	16.7332	6.5421
232	15.2315	6.1446	281	16.7630	6.5499
233	15.2643	6.1534	282	16.7928	6.5576
234	15.2970	6.1622	283	16.8226	6.5654
235	15.3297	6.1710	284	16.8522	6.5731
236	15.3622	6.1797	285	16.8819	6.5808
237	15.3948	6.1884	286	16.9115	6.5885

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
287	16.9410	6.5962	336	18.3303	6.9520
288	16.9705	6.6038	337	18.3575	6.9589
289	17.0000	6.6114	338	18.3847	6.9658
290	17.0293	6.6191	339	18.4119	6.9726
291	17.0587	6.6267	340	18.4390	6.9795
292	17.0880	6.6342	341	18.4661	6.9863
293	17.1172	6.6418	342	18.4932	6.9931
294	17.1464	6.6493	343	18.5202	7.0000
295	17.1755	6.6569	344	18.5472	7.0067
296	17.2046	6.6644	345	18.5741	7.0135
297	17.2336	6.6719	346	18 6010	7.0203
298	17.2626	6.6794	347	18.6279	7.0271
299	17.2916	6.6868	348	18.6547	7.0338
300	17.3205	6.6943	349	18.6815	7.0405
301	17.3493	6.7017	350	18.7082	7.0472
302	17.3781	6.7091	351	18.7349	7.0540
303	17.4068	6.7165	352	18.7616	7.0606
304	17.4355	6.7239	353	18.7882	7.0673
305	17.4642	6.7313	354	18.8148	7.0740
306	17.4928	6.7386	355	18.8414	7.0806
307	17.5214	6.7459	356	18.8679	7.0873
308	17.5499	6.7533	357	18.8944	7.0939
309	17.5783	6.7606	358	18.9208	7.1005
310	17.6068	6.7678	359	18.9472	7.1071
311	17.6351	6.7751	360	18.9736	7.1137
312	17.6635	6.7824	361	19.0000	7.1203
313	17.6918	6.7896	362	19.0262	7.1269
314	17.7200	6.7968	363	19.0525	7.1334
315	17.7482	6 8040	364	19.0787	7.1400
316	17.7763	6.8112	365	19.1049	7.1465
317	17.8044	6.8184	366	19.1311	7.1530
318	17.8325	6.8256	367	19.1572	7.1595
319	17.8605	6.8327	368	19.1833	7.1660
320	17.8885	6.8399	369	19.2093	7.1725
321	17.9164	6.8470	370	19.2353	7.1790
322	17.9443	6.8541	371	19.2613	7.1855
323	17.9722	6.8612	372	19.2873	7.1919
324	18.0000	6.8682	373	19.3132	7.1984
325	18.0277	6.8753	374	19 3390	7.2048
326	18.0554	6.8823	375	19.3649	7.2112
327	18.0831	6.8894	376	19.3907	7.2176
328	18.1107	6.8964	377	19.4164	7.2240
329	18.1383	6.9034	378	19.4422	7.2304
330	18.1659	6.9104	379	19.4679	7.2367
331	18.1934	6 9173	380	19.4935	7.2431
332	18.2208	6.9243	381	19.5192	7.2495
333	18.2482	6.9313	382	19.5448	7.2558
334	18.2756	6.9383	383	19 5703	7.2621
335	18.3030	6.9451	384	19.5959	7.2684

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
385	19.6214	7.2747	434	20.8326	7.5711
386	19.6468	7.2810	435	20.8566	7.5769
387	19.6723	7.2873	436	20.8806	7.5827
388	19.6977	7.2936	437	20.9045	7.5885
389	19.7230	7.2998	438	20.9284	7.5943
390	19.7484	7.3061	439	20.9523	7.6001
391	19.7737	7.3123	440	20.9761	7.6059
392	19.7989	7.3186	441	21.0000	7.6116
393	19.8242	7.3248	442	21.0237	7.6174
394	19.8494	7.3310	443	21.0457	7.6231
395	19.8746	7.3372	444	21.0713	7.6288
396	19.8997	7.3434	445	21.0950	7.6346
397	19.9248	7.3495	446	21.1187	7.6403
398	19.9499	7.3557	447	21.1423	7.6460
399	19.9749	7.3619	448	21.1660	7.6517
400	20.0000	7.3680	449	21.1896	7.6574
401	20.0249	7.3741	450	21.2132	7.6630
402	20 0499	7.3803	451	21.2367	7.6687
403	20.0748	7.3864	452	21.2602	7.6744
404	20.0997	7.3925	453	21.2837	7.6800
405	20.1246	7.3986	454	21.3072	7.6857
406	20.1494	7.4047	455	21.3307	7.6913
407	20.1742	7.4107	456	21.3541	7.6970
408	20.1990	7.4168	457	21.3775	7.7026
409	20.2237	7.4229	458	21.4009	7.7082
410	20.2484	7.4289	459	21.4242	7.7138
411	20.2731	7.4349	460	21.4476	7.7194
412	20.2977	7.4410	461	21.4709	7.7250
413	20.3224	7.4470	462	21.4941	7.7306
414	20.3469	7.4530	463	21.5174	7.7361
415	20.3715	7.4590	464	21.5406	7.7417
416	20.3960	7.4650	465	21.5638	7.7473
417	20.4205	7.4709	466	21.5870	7.7528
418	20.4450	7.4769	467	21.6101	7.7584
419	20.4694	7.4829	468	21.6333	7.7639
420	20.4939	7.4888	469	21.6564	7.7694
421	20.5182	7.4948	470	21.6794	7.7749
422	20.5426	7.5007	471	21.7025	7.7804
423	20.5669	7.5066	472	21.7255	7.7859
424	20.5912	7.5125	473	21.7485	7.7914
425	20.6155	7.5184	474	21.7715	7.7969
426	20.6397	7.5243	475	21.7944	7.8024
427	20.6639	7.5302	476	21.8174	7.8079
428	20.6881	7.5361	477	21.8403	7.8133
429	20.7123	7.5419	478	21.8632	7.8188
430	20.7364	7.5478	479	21.8860	7.8242
431	20.7605	7.5536	480	21.9089	7.8297
432	20.7846	7.5595	481	21.9317	7.8351
433	20.8086	7.5653	482	21.9544	7.8405

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
483	21.9772	7.8460	532	23.0651	8.1028
484	22.0000	7.8514	533	23.0867	8.1079
485	22.0227	7.8568	534	23.1084	8.1129
486	22.0454	7.8622	535	23.1300	8.1180
487	22.0680	7.8676	536	23.1516	8.1230
488	22.0907	7.8729	537	23.1732	8.1281
489	22.1133	7.8783	538	23.1948	8.1331
490	22.1359	7.8837	539	23.2163	8.1382
491	22.1585	7.8890	540	23.2379	8.1432
492	22.1810	7.8944	541	23.2594	8.1482
493	22.2036	7.8997	542	23.2808	8.1532
494	22.2261	7.9051	543	23.3023	8.1583
495	22.2485	7.9104	544	23.3238	8.1633
496	22.2710	7.9157	545	23.3452	8.1683
497	22.2934	7.9210	546	23.3666	8.1733
498	22.3159	7.9264	547	23.3880	8.1782
499	22.3383	7.9317	548	23.4093	8.1832
500	22.3606	7.9370	549	23.4307	8.1882
501	22.3830	7.9422	550	23.4520	8.1932
502	22.4053	7.9475	551	23.4733	8.1981
503	22.4276	7.9528	552	23.4946	8.2031
504	22.4499	7.9581	553	23.5159	8.2080
505	22.4722	7.9633	554	23.5372	8.2130
506	22.4944	7.9686	555	23.5584	8.2179
507	22.5166	7.9738	556	23.5796	8.2228
508	22.5388	7.9791	557	23.6008	8.2278
509	22.5610	7.9843	558	23.6220	8.2327
510	22.5831	7.9895	559	23.6431	8.2376
511	22.6053	7.9947	560	23.6643	8.2425
512	22.6274	8.0000	561	23.6854	8.2474
513	22.6495	8.0052	562	23.7065	8.2523
514	22.6715	8.0104	563	23.7276	8.2572
515	22.6936	8.0155	564	23.7486	8.2621
516	22.7156	8.0207	565	23.7697	8.2670
517	22.7376	8.0259	566	23.7907	8.2719
518	22.7596	8.0311	567	23.8117	8.2767
519	22.7815	8.0362	568	23.8327	8.2816
520	22.8035	8.0414	569	23.8537	8.2864
521	22.8254	8.0466	570	23.8746	8.2913
522	22.8473	8.0517	571	23.8956	8.2961
523	22.8691	8.0568	572	23.9165	8.3010
524	22.8910	8.0620	573	23.9374	8.3058
525	22.9128	8.0671	574	23.9582	8.3106
526	22.9346	8.0722	575	23.9791	8.3155
527	22.9564	8.0773	576	24.0000	8.3203
528	22.9782	8.0824	577	24.0208	8.3251
529	23.0000	8.0875	578	24.0416	8.3299
530	23.0217	8.0926	579	24.0624	8.3347
531	23.0434	8.0977	580	24.0831	8.3395

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
581	24.1039	8.3443	630	25.0998	8.5726
582	24.1246	8.3491	631	25.1197	8.5771
583	24.1453	8.3539	632	25.1396	8.5816
584	24.1660	8.3586	633	25.1594	8.5862
585	24.1867	8.3634	634	25.1793	8.5907
586	24.2074	8.3682	635	25.1992	8.5952
587	24.2280	8.3729	636	25.2190	8.5997
588	24.2487	8.3777	637	25.2388	8.6042
589	24.2693	8.3824	638	25.2586	8.6087
590	24.2899	8.3872	639	25.2784	8.6132
591	24.3104	8.3919	640	25.2982	8.6177
592	24.3310	8.3966	641	25.3179	8.6222
593	24.3515	8.4013	642	25.3377	8.6267
594	24.3721	8.4061	643	25.3574	8.6311
595	24.3926	8.4108	644	25.3771	8.6356
596	24.4131	8.4155	645	25.3968	8.6401
597	24.4336	8.4202	646	25.4165	8.6445
598	24.4540	8.4249	647	25.4361	8.6490
599	24.4744	8.4296	648	25.4558	8.6534
600	24.4948	8.4343	649	25.4754	8.6579
601	24.5153	8.4390	650	25.4950	8.6623
602	24.5356	8.4436	651	25.5147	8.6668
603	24.5560	8.4483	652	25.5342	8.6712
604	24.5764	8.4530	653	25.5538	8.6756
605	24.5967	8.4576	654	25.5734	8.6801
606	24.6170	8.4623	655	25.5929	8.6845
607	24.6373	8.4670	656	25.6124	8.6889
608	24.6576	8.4716	657	25.6320	8.6933
609	24.6779	8.4762	658	25.6515	8.6977
610	24.6981	8.4809	659	25.6709	8.7021
611	24.7184	8.4855	660	25.6904	8.7065
612	24.7386	8.4901	661	25.7099	8.7109
613	24.7588	8.4948	662	25.7293	8.7153
614	24.7790	8.4994	663	25.7487	8.7197
615	24.7991	8.5040	664	25.7681	8.7241
616	24.8193	8.5086	665	25.7875	8.7285
617	24.8394	8.5132	666	25.8069	8.7328
618	24.8596	8.5178	667	25.8263	8.7372
619	24.8797	8.5224	668	25.8456	8.7416
620	24.8997	8.5270	669	25.8650	8.7459
621	24.9198	8.5316	670	25.8843	8.7503
622	24.9399	8.5361	671	25.9036	8.7546
623	24.9599	8.5407	672	25.9229	8.7590
624	24.9799	8.5453	673	25.9422	8.7633
625	25.0000	8.5498	674	25.9615	8.7677
626	25.0199	8.5544	675	25.9807	8.7720
627	25.0399	8.5589	676	26.0000	8.7763
628	25.0599	8.5635	677	26.0192	8.7807
629	25.0798	8.5680	678	26.0384	8.7850

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
679	26.0576	8.7893	728	26.9814	8.9958
680	26.0768	8.7936	729	27.0000	9.0000
681	26.0959	8.7979	730	27.0185	9.0041
682	26.1151	8.8022	731	27.0370	9.0082
683	26.1342	8.8065	732	27.0554	9.0123
684	26.1533	8.8108	733	27.0739	9.0164
685	26.1725	8.8151	734	27.0924	9.0205
686	26.1916	8.8194	735	27.1108	9.0246
687	26.2106	8.8237	736	27.1293	9.0287
688	26.2297	8.8280	737	27.1477	9.0328
689	26.2488	8.8322	738	27.1661	9.0368
690	26.2678	8.8365	739	27.1845	9.0409
691	26.2868	8.8408	740	27.2029	9.0450
692	26.3058	8.8450	741	27.2213	9.0491
693	26.3248	8.8493	742	27.2396	9.0531
694	26.3438	8.8535	743	27.2580	9.0572
695	26.3628	8.8578	744	27.2763	9.0613
696	26.3818	8.8620	745	27.2946	9.0653
697	26.4007	8.8663	746	27.3130	9.0694
698	26.4196	8.8705	747	27.3313	9.0734
699	26.4386	8.8748	748	27.3495	9.0775
700	26.4575	8.8790	749	27.3678	9.0815
701	26.4764	8.8832	750	27.3861	9.0856
702	26.4952	8.8874	751	27.4043	9.0896
703	26.5141	8.8917	752	27.4226	9.0936
704	26.5329	8.8959	753	27.4408	9.0977
705	26.5518	8.9001	754	27.4590	9.1017
706	26.5706	8.9043	755	27.4772	9.1057
707	26.5894	8.9085	756	27.4954	9.1097
708	26.6082	8.9127	757	27.5136	9.1137
709	26.6270	8.9169	758	27.5317	9.1177
710	26.6458	8.9211	759	27.5499	9.1218
711	26.6645	8.9253	760	27.5680	9.1258
712	26.6833	8.9294	761	27.5862	9.1298
713	26.7020	8.9336	762	27.6043	9.1338
714	26.7207	8.9378	763	27.6224	9.1377
715	26.7394	8.9420	764	27.6405	9.1417
716	26.7581	8.9461	765	27.6586	9.1457
717	26.7768	8.9503	766	27.6767	9.1497
718	26.7955	8.9545	767	27.6947	9.1537
719	26.8141	8.9586	768	27.7128	9.1577
720	26.8328	8.9628	769	27.7308	9.1616
721	26.8514	8.9669	770	27.7488	9.1656
722	26.8700	8.9711	771	27.7668	9.1696
723	26.8886	8.9752	772	27.7848	9.1735
724	26.9072	8.9793	773	27.8028	9.1775
725	26.9258	8.9835	774	27.8208	9.1815
726	26.9443	8.9876	775	27.8388	9.1854
727	26.9629	8.9917	776	27.8567	9.1894

Numb.	*Square Roots.*	*Cube Roots.*	*Numb.*	*Square Roots.*	*Cube Roots.*
777	27.8747	9.1933	826	28.7402	9.3826
778	27.8926	9.1972	827	28.7576	9.3864
779	27.9105	9.2012	828	28.7749	9.3902
780	27.9284	9 2051	829	28.7923	9.3940
781	27.9463	9.2090	830	28.8097	9.3977
782	27.9642	9.2130	831	28.8270	9.4015
783	27.9821	9.2169	832	28.8444	9.4053
784	28.0000	9.2208	833	28.8617	9.4091
785	28.0178	9.2247	834	28.8790	9.4128
786	28.0356	9.2287	835	28.8963	9.4166
787	28.0535	9.2326	836	28 9136	9.4203
788	28.0713	9.2365	837	28.9309	9.4241
789	28.0891	9.2404	838	28 9482	9.4278
790	28.1069	9.2443	839	28.9654	9.4316
791	28.1247	9.2482	840	28.9827	9.4353
792	28.1424	9.2521	841	29.0000	9.4391
793	28.1602	9.2560	842	29.0172	9.4428
794	28.1780	9.2599	843	29.0344	9.4466
795	28.1957	9.2637	844	29.0516	9.4503
796	28.2134	9.2676	845	29.0688	9.4540
797	28.2311	9.2715	846	29.0860	9.4577
798	28.2488	9.2754	847	29.1032	9.4615
799	28.2665	9.2793	848	29.1204	9.4652
800	28.2842	9.2831	849	29.1376	9.4689
801	28.3019	9.2870	850	29.1547	9.4726
802	28.3196	9.2909	851	29.1719	9.4761
803	28.3372	9.2947	852	29.1890	9.4801
804	28.3548	9.2986	853	29 2061	9.4838
805	28.3725	9.3024	854	29.2232	9.4875
806	28.3901	9.3063	855	29.2403	9.4912
807	28.4077	9.3101	856	29.2574	9.4949
808	28.4253	9.3140	857	29.2745	9.4986
809	28.4429	9.3178	858	29.2916	9.5023
810	28.4604	9.3216	859	29.3087	9.5059
811	28.4780	9.3255	860	29·3257	9.5096
812	28.4956	9.3293	861	29.3428	9.5133
813	28.5131	9.3331	862	29.3598	9.5170
814	28.5306	9 3370	863	29.3768	9.5207
815	28.5482	9.3408	864	29.3938	9.5244
816	28.5657	9.3446	865	29.4108	9.5280
817	28.5832	9.3484	866	29.4278	9.5317
818	28.6006	9.3522	867	29.4448	9.5354
819	28.6181	9.3560	868	29.4618	9.5390
820	28.6356	9.3599	869	29.4788	9.5427
821	28.6530	9.3637	870	29.4957	9.5464
822	28.6705	9.3675	871	29.5127	9.5500
823	28.6379	9.3713	872	29.5296	9.5537
824	28 7054	9.3750	873	29.5465	9.5573
825	28.7228	9.3788	874	29.5634	9.5610

Numb	Square Roots.	Cube Roots	Numb.	Square Roots	Cube Roots.
875	29.5803	9.5646	924	30 3973	9.7399
876	29 5972	9.5683	925	30.4138	9.7434
877	29.6141	9.5719	926	30.4302	9.7469
878	29.6310	9.5755	927	30.4466	9.7504
879	29.6479	9 5792	928	30.4630	9.7539
880	29.6647	9.5828	929	30.4795	9.7575
881	29.6816	9.5864	930	30.4959	9.7610
882	29.6984	9.5900	931	30.5122	9.7644
883	29.7153	9.5937	932	30.5286	9.7679
884	29.7321	9.5973	933	30 5450	9.7714
885	29.7489	9.6009	934	30.5614	9.7749
886	29.7657	9.6045	935	30.5777	9.7784
887	29.7825	9.6081	936	30.5941	9.7829
888	29.7993	9.6117	937	30.6104	9.7854
889	29.8161	9.6153	938	30.6267	9.7889
890	29.8328	9.6190	939	30.6431	9.7923
891	29.8496	9.6226	940	30.6594	9.7958
892	29.8663	9.6262	941	30.6757	9.7993
893	29.8831	9.6297	942	30.6920	9.8028
894	29.8998	9.6333	943	30.7083	9.8062
895	29.9165	9.6369	944	30.7245	9.8097
896	29.9332	9.6405	945	30.7408	9.8131
897	29.9499	9.6441	946	30.7571	9 8166
898	29.9666	9.6477	947	30.7733	9.8201
899	29.9833	9.6513	948	30.7896	9.8235
900	30.0000	9.6548	949	30.8058	9.8270
901	30.0166	9.6584	950	30.8220	9.8304
902	30.0333	9.6620	951	30.8382	9.8339
903	30.0499	9.6656	952	30.8544	9.8373
904	30.0665	9.6691	953	30.8706	9.8408
905	30 0832	9.6727	954	30.8868	9.8442
906	30 0998	9.6763	955	30.9030	9.8476
907	30.1164	9.6798	956	30.9192	9.8511
908	30.1330	9.6834	957	30.9354	9.8545
909	30.1496	9.6869	958	30.9515	9.8579
910	30.1662	9.6905	959	30.9677	9.8614
911	30 1827	9.6940	960	30.9838	9.8648
912	30.1993	9.6976	961	31.0000	9.8682
913	30.2158	9.7011	962	31.0161	9.8716
914	30.2324	9.7046	963	31.0322	9.8751
915	30 2489	9.7082	964	31.0483	9.8785
916	30.2654	9 7117	965	31.0644	9.8819
917	30.2820	9.7153	966	31.0805	9.8853
918	30.2985	9.7188	967	31 0966	9.8887
919	30.3150	9.7223	968	31.1126	9.8921
920	30.3315	9.7258	969	31.1287	9 8955
921	30.3479	9.7294	970	31.1448	9.8989
922	30.3644	9 7329	971	31.1608	9 9023
923	30.3809	9.7364	972	31.1769	9.9057

Numb.	Square Roots.	Cube Roots	Numb.	Square Roots.	Cube Roots.
973	31.1929	9.9091	1022	31.9687	10 0728
974	31.2089	9.9125	1023	31.9843	10 0760
975	31.2249	9.9159	1024	32.0000	10.0793
976	31.2409	9.9193	1025	32.0156	10 0826
977	31.2569	9 9227	1026	32.0312	10.0859
978	31.2729	9.9261	1027	32 0468	10.0892
979	31 2889	9.9295	1028	32.0624	10.0924
980	31.3049	9.9328	1029	32.0780	10.0957
981	31.3209	9.9362	1030	32 0936	10.0990
982	31.3368	9.9396	1031	32.1091	10.1022
983	31.3528	9.9430	1032	32.1247	10.1055
984	31.3687	9 9463	1033	32.1403	10.1088
985	31.3847	9.9497	1034	32 1558	10.1120
986	31.4006	9.9531	1035	32.1714	10 1153
987	31.4165	9 9564	1036	32 1869	10.1185
988	31.4324	9.9598	1037	32.2024	10.1218
989	31.4483	9.9631	1038	32.2180	10.1250
990	31.4642	9 9665	1039	32.2335	10.1283
991	31.4801	9 9699	1040	32.2490	10.1315
992	31.4960	9.9732	1041	32.2645	10.1348
993	31.5119	9.9766	1042	32 2800	10.1380
994	31.5277	9 9799	1043	32.2955	10.1413
995	31.5436	9.9833	1044	32 3109	10.1445
996	31.5594	9.9866	1045	32.3264	10.1478
997	31.5753	9.9899	1046	32.3419	10.1510
998	31 5911	9.9933	1047	32.3573	10 1542
999	31.6069	9.9966	1048	32.3728	10.1575
1000	31.6227	10.0000	1049	32 3882	10.1607
1001	31.6385	10.0033	1050	32.4037	10.1639
1002	31.6543	10.0066	1051	32.4191	10.1671
1003	31.6701	10.0099	1052	32.4345	10 1704
1004	31.6859	10 0133	1053	32.4499	10.1736
1005	31.7017	10.0166	1054	32.4653	10.1768
1006	31.7175	10.0199	1055	32.4807	10 1800
1007	31.7332	10.0232	1056	32 4961	10.1832
1008	31.7490	10.0265	1057	32.5115	10.1865
1009	31.7647	10.0299	1058	32.5269	10 1897
1010	31.7804	10.0332	1059	32.5422	10.1929
1011	31.7962	10.0365	1060	32.5576	10.1961
1012	31.8119	10.0398	1061	32.5729	10.1993
1013	31.8276	10.0431	1062	32 5883	10.2025
1014	31.8433	10.0464	1063	32.6036	10.2057
1015	31.8590	10.0497	1064	32.6190	10 2089
1016	31.8747	10 0530	1065	32.6343	10.2121
1017	31.8904	10.0563	1066	32.6496	10.2153
1018	31.9061	10.0596	1067	32 6649	10.2185
1019	31.9217	10.0629	1068	32.6802	10.2217
1020	31.9374	10.0662	1069	32.6955	10.2249
1021	31.9530	10 0695	1070	32.7108	10.2280

Numb.	*Square Roots.*	*Cube Roots.*	*Numb.*	*Square Roots*	*Cube Roots.*
1071	32.7261	10.2312	1120	33.4664	10.3849
1072	32.7414	10.2344	1121	33.4813	10.3880
1073	32.7566	10.2376	1122	33.4962	10.3911
1074	32.7719	10.2408	1123	33.5111	10.3942
1075	32.7871	10.2439	1124	33.5261	10.3973
1076	32.8024	10.2471	1125	33.5410	10.4004
1077	32.8176	10.2503	1126	33.5559	10.4034
1078	32.8329	10.2535	1127	33.5708	10.4065
1079	32.8481	10.2566	1128	33.5857	10.4096
1080	32.8633	10.2598	1129	33.6005	10.4127
1081	32.8785	10.2630	1130	33.6154	10.4158
1082	32.8937	10.2661	1131	33.6303	10.4188
1083	32.9089	10.2693	1132	33.6452	10.4219
1084	32.9241	10.2725	1133	33.6600	10.4250
1085	32.9393	10.2756	1134	33.6749	10.4280
1086	32.9545	10.2788	1135	33.6897	10.4311
1087	32.9696	10.2819	1136	33.7045	10.4342
1088	32.9848	10.2851	1137	33.7194	10.4372
1089	33.0000	10.2882	1138	33.7342	10.4403
1090	33.0151	10.2914	1139	33.7490	10.4433
1091	33.0302	10.2945	1140	33.7638	10.4464
1092	33.0454	10.2977	1141	33.7786	10.4494
1093	33.0605	10.3008	1142	33.7934	10.4525
1094	33.0756	10.3039	1143	33.8082	10.4555
1095	33.0907	10.3071	1144	33.8230	10.4586
1096	33.1058	10.3102	1145	33.8378	10.4616
1097	33.1209	10.3134	1146	33.8526	10.4647
1098	33.1360	10.3165	1147	33.8673	10.4677
1099	33.1511	10.3196	1148	33.8821	10.4708
1100	33.1662	10.3228	1149	33.8969	10.4738
1101	33.1813	10.3259	1150	33.9116	10.4768
1102	33.1963	10.3290	1151	33.9263	10.4799
1103	33.2114	10.3321	1152	33.9411	10.4829
1104	33.2264	10.3352	1153	33.9558	10.4859
1105	33.2415	10.3384	1154	33.9705	10.4890
1106	33.2565	10.3415	1155	33.9852	10.4920
1107	33.2716	10.3446	1156	34.0000	10.4950
1108	33.2866	10.3477	1157	34.0147	10.4981
1109	33.3016	10.3508	1158	34.0293	10.5011
1110	33.3166	10.3539	1159	34.0440	10.5041
1111	33.3316	10.3570	1160	34.0587	10.5071
1112	33.3466	10.3602	1161	34.0734	10.5101
1113	33.3616	10.3633	1162	34.0881	10.5132
1114	33.3766	10.3664	1163	34.1027	10.5162
1115	33.3916	10.3695	1164	34.1174	10.5192
1116	33.4065	10.3726	1165	34.1320	10.5222
1117	33.4215	10.3757	1166	34.1467	10.5252
1118	33.4365	10.3788	1167	34.1613	10.5282
1119	33.4514	10.3818	1168	34.1760	10.5312

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots	Cube Roots
1169	34.1906	10.5342	1218	34.8998	10.6794
1170	34.2052	10.5372	1219	34.9141	10.6823
1171	34.2198	10.5402	1220	34.9284	10.6852
1172	34.2344	10.5432	1221	34.9428	10.6882
1173	34.2490	10.5462	1222	34.9571	10.6911
1174	34.2636	10.5492	1223	34.9714	10.6940
1175	34.2782	10.5522	1224	34.9857	10.6969
1176	34.2928	10.5552	1225	35.0000	10.6998
1177	34.3074	10.5582	1226	35.0142	10.7027
1178	34.3220	10.5612	1227	35.0285	10.7056
1179	34.3365	10.5642	1228	35.0428	10.7086
1180	34.3511	10.5672	1229	35.0570	10.7115
1181	34.3656	10.5702	1230	35.0713	10.7144
1182	34.3802	10.5731	1231	35.0856	10.7173
1183	34.3947	10.5761	1232	35.0998	10.7202
1184	34.4093	10.5791	1233	35.1140	10.7231
1185	34.4238	10.5821	1234	35.1283	10.7260
1186	34.4383	10.5850	1235	35.1425	10.7289
1187	34.4528	10.5880	1236	35.1567	10.7318
1188	34.4673	10.5910	1237	35.1710	10.7346
1189	34.4818	10.5940	1238	35.1852	10.7375
1190	34.4963	10.5969	1239	35.1994	10.7404
1191	34.5108	10.5999	1240	35.2136	10.7433
1192	34.5253	10.6029	1241	35.2278	10.7462
1193	34.5398	10.6058	1242	35.2420	10.7491
1194	34.5543	10.6088	1243	35.2562	10.7520
1195	34.5687	10.6118	1244	35.2703	10.7549
1196	34.5832	10.6147	1245	35.2845	10.7577
1197	34.5976	10.6177	1246	35.2987	10.7606
1198	34.6121	10.6206	1247	35.3128	10.7635
1199	34.6265	10.6236	1248	35.3270	10.7664
1200	34.6410	10.6265	1249	35.3411	10.7693
1201	34.6554	10.6295	1250	35.3553	10.7721
1202	34.6698	10.6324	1251	35.3694	10.7750
1203	34.6842	10.6354	1252	35.3836	10.7779
1204	34.6987	10.6383	1253	35.3977	10.7807
1205	34.7131	10.6413	1254	35.4118	10.7836
1206	34.7275	10.6442	1255	35.4259	10.7865
1207	34.7419	10.6472	1256	35.4400	10.7893
1208	34.7562	10.6501	1257	35.4541	10.7922
1209	34.7706	10.6530	1258	35.4682	10.7951
1210	34.7850	10.6560	1259	35.4823	10.7979
1211	34.7994	10.6589	1260	35.4964	10.8008
1212	34.8137	10.6618	1261	35.5105	10.8036
1213	34.8281	10.6648	1262	35.5246	10.8065
1214	34.8425	10.6677	1263	35.5387	10.8093
1215	34.8568	10.6706	1264	35.5527	10.8122
1216	34.8711	10.6736	1265	35.5668	10.8150
1217	34.8855	10.6765	1266	35.5808	10.8179

Numb.	Square Roots.	Cube Roots	Numb.	Square Roots.	Cube Roots.
1267	35.5949	10.8207	1316	36.2767	10.9585
1268	35.6089	10.8236	1317	36.2904	10.9612
1269	35.6230	10.8264	1318	36.3042	10.9640
1270	35.6370	10.8293	1319	36.3180	10.9668
1271	35.6510	10.8321	1320	36.3318	10 9696
1272	35.6651	10 8350	1321	36.3455	10.9723
1273	35.6791	10 8378	1322	36.3593	10.9751
1274	35.6931	10.8406	1323	36.3730	10.9779
1275	35.7071	10.8435	1324	36.3868	10.9806
1276	35.7211	10.8463	1325	36.4005	10.9834
1277	35.7351	10.8491	1326	36.4142	10.9862
1278	35.7491	10.8520	1327	36.4280	10.9889
1279	35.7631	10.8548	1328	36.4417	10.9917
1280	35.7770	10.8576	1329	36.4554	10.9944
1281	35.7910	10.8604	1330	36.4691	10.9972
1282	35.8050	10.8633	1331	36 4828	11.0000
1283	35.8189	10 8661	1332	36.4965	11.0027
1284	35.8329	10.8689	1333	36.5102	11.0055
1285	35.8468	10.8717	1334	36 5239	11.0082
1286	35.8608	10.8746	1335	36 5376	11.0110
1287	35.8747	10.8774	1336	36.5513	11.0137
1288	35.8887	10 8802	1337	36.5650	11.0165
1289	35.9026	10.8830	1338	36.5786	11.0192
1290	35.9165	10.8858	1339	36.5923	11.0219
1291	35.9304	10.8886	1340	36.6060	11.0247
1292	35.9444	10.8914	1341	36.6196	11.0274
1293	35.9583	10.8943	1342	36.6333	11.0302
1294	35.9722	10.8971	1343	36.6469	11.0329
1295	35.9861	10.8999	1344	36.6606	11.0356
1296	36.0000	10 9027	1345	36.6742	11.0384
1297	36.0138	10.9055	1346	36.6878	11.0411
1298	36.0277	10.9083	1347	36.7014	11.0439
1299	36.0416	10.9111	1348	36 7151	11.0466
1300	36.0555	10.9139	1349	36 7287	11.0493
1301	36.0693	10.9167	1350	36.7423	11.0520
1302	36.0832	10.9195	1351	36.7559	11.0548
1303	36.0970	10.9223	1352	36.7695	11.0575
1304	36.1109	10.9251	1353	36.7831	11.0602
1305	36.1247	10.9279	1354	36.7967	11.0629
1306	36.1386	10.9306	1355	36.8103	11.0657
1307	36.1524	10.9334	1356	36.8239	11.0684
1308	36.1662	10.9362	1357	36.8374	11.0711
1309	36.1801	10.9390	1358	36.8510	11.0738
1310	36.1939	10.9418	1359	36.8646	11.0766
1311	36.2077	10.9446	1360	36.8781	11.0793
1312	36.2215	10.9474	1361	36.8917	11.0820
1313	36.2353	10.9501	1362	36 9052	11.0847
1314	36.2491	10.9529	1363	36.9188	11.0874
1315	36.2629	10.9557	1364	36.9323	11.0901

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
1365	36.9459	11.0928	1414	37.6031	11.2240
1366	36.9594	11.0955	1415	37.6164	11.2267
1367	36.9729	11.0982	1416	37.6297	11.2293
1368	36.9864	11.1009	1417	37.6430	11.2319
1369	37.0000	11.1037	1418	37.6563	11.2346
1370	37.0135	11.1064	1419	37.6696	11.2372
1371	37.0270	11.1091	1420	37.6828	11.2399
1372	37.0405	11.1118	1421	37.6961	11.2425
1373	37.0540	11.1145	1422	37.7094	11.2451
1374	37.0675	11.1172	1423	37.7226	11.2478
1375	37.0809	11.1199	1424	37.7359	11.2504
1376	37.0944	11.1225	1425	37.7491	11.2530
1377	37.1079	11.1252	1426	37.7624	11.2557
1378	37.1214	11.1279	1427	37.7756	11.2583
1379	37.1348	11.1306	1428	37.7888	11.2609
1380	37.1483	11.1333	1429	37.8021	11.2636
1381	37.1618	11.1360	1430	37.8153	11.2662
1382	37.1752	11.1387	1431	37.8285	11.2688
1383	37.1887	11.1414	1432	37.8417	11.2714
1384	37 2021	11.1441	1433	37.8549	11.2741
1385	37.2155	11.1467	1434	37.8681	11.2767
1386	37.2290	11.1494	1435	37.8813	11.2793
1387	37.2424	11.1521	1436	37.8945	11.2819
1388	37.2558	11.1548	1437	37.9077	11.2845
1389	37.2692	11.1575	1438	37.9209	11.2872
1390	37.2827	11.1601	1439	37.9341	11.2898
1391	37.2961	11.1628	1440	37.9473	11.2924
1392	37.3095	11.1655	1441	37.9605	11.2950
1393	37.3229	11.1682	1442	37.9736	11.2976
1394	37.3363	11.1708	1443	37.9868	11.3002
1395	37 3496	11.1735	1444	38.0000	11.3028
1396	37.3630	11.1762	1445	38.0131	11.3054
1397	37.3764	11.1788	1446	38 0263	11.3080
1398	37.3898	11.1815	1447	38.0394	11.3107
1399	37.4032	11.1842	1448	38.0525	11.3133
1400	37.4165	11.1868	1449	38.0657	11.3159
1401	37 4299	11.1895	1450	38.0788	11.3185
1402	37.4432	11.1922	1451	38.0919	11.3211
1403	37.4566	11.1948	1452	38.1051	11.3237
1404	37.4699	11.1975	1453	38.1182	11.3263
1405	37.4833	11.2001	1454	38.1313	11.3289
1406	37 4966	11.2028	1455	38.1444	11.3315
1407	37.5099	11.2055	1456	38.1575	11.3341
1408	37.5233	11 2081	1457	38.1706	11.3366
1409	37.5366	11.2108	1458	38.1837	11.3392
1410	37.5499	11.2134	1459	38.1968	11.3418
1411	37.5632	11.2161	1460	38 2099	11.3444
1412	37.5765	11.2187	1461	38 2230	11.3470
1413	37.5898	11 2214	1462	38.2361	11.3496

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
1463	38.2491	11.3522	1512	38.8844	11.4775
1464	38.2622	11.3548	1513	38 8973	11.4801
1465	38.2753	11.3574	1514	38.9101	11.4826
1466	38.2883	11.3599	1515	38.9230	11.4851
1467	38.3014	11.3625	1516	38.9358	11.4876
1468	38 3144	11.3651	1517	38.9486	11.4902
1469	38.3275	11.3677	1518	38.9615	11.4927
1470	38.3405	11.3703	1519	38 9743	11.4952
1471	38.3536	11.3728	1520	38.9871	11.4977
1472	38.3666	11.3754	1521	39.0000	11.5003
1473	38.3796	11.3780	1522	39.0128	11.5028
1474	38.3927	11.3806	1523	39 0256	11.5053
1475	38.4057	11.3831	1524	39.0384	11.5078
1476	38.4187	11.3857	1525	39.0512	11 5103
1477	38.4317	11.3883	1526	39 0640	11.5129
1478	38.4447	11.3909	1527	39.0768	11.5154
1479	38.4577	11.3934	1528	39.0896	11.5179
1480	38.4707	11.3960	1529	39.1024	11.5204
1481	38.4837	11.3986	1530	39.1152	11.5229
1482	38 4967	11.4011	1531	39.1279	11.5254
1483	38.5097	11.4037	1532	39.1407	11.5279
1484	38.5227	11.4062	1533	39.1535	11.5304
1485	38.5356	11.4088	1534	39.1663	11.5329
1486	38.5486	11.4114	1535	39.1790	11.5354
1487	38.5616	11.4139	1536	39.1918	11.5379
1488	38.5746	11.4165	1537	39.2045	11.5404
1489	38.5875	11.4190	1538	39 2173	11.5430
1490	38.6005	11.4216	1539	39.2300	11.5455
1491	38.6134	11.4242	1540	39.2428	11.5480
1492	38.6264	11.4267	1541	39.2555	11.5505
1493	38.6393	11.4293	1542	39 2683	11.5530
1494	38.6522	11.4318	1543	39.2810	11.5554
1495	38.6652	11.4344	1544	39.2937	11.5579
1496	38.6781	11.4369	1545	39.3064	11.5604
1497	38.6910	11.4395	1546	39.3192	11.5629
1498	38.7040	11.4420	1547	39.3319	11.5654
1499	38.7169	11.4445	1548	39.3446	11.5679
1500	38.7298	11.4471	1549	39.3573	11.5704
1501	38 7427	11.4496	1550	39.3700	11.5729
1502	38.7556	11.4522	1551	39.3827	11.5754
1503	38.7685	11.4547	1552	39.3954	11.5779
1504	38 7814	11.4573	1553	39.4081	11.5804
1505	38.7943	11.4598	1554	39.4208	11.5828
1506	38.8072	11.4623	1555	39.4334	11.5853
1507	38.8200	11.4649	1556	39.4461	11.5878
1508	38.8329	11.4674	1557	39.4588	11.5903
1509	38.8458	11.4699	1558	39.4715	11.5928
1510	38.8587	11.4725	1559	39.4841	11.5953
1511	38.8715	11.4750	1560	39.4968	11.5977

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
1561	39.5094	11.6002	1610	40.1248	11.7203
1562	39.5221	11.6027	1611	40.1372	11.7228
1563	39.5347	11.6052	1612	40.1497	11.7252
1564	39.5474	11.6076	1613	40.1621	11.7276
1565	39.5600	11.6101	1614	40.1746	11.7300
1566	39.5727	11.6126	1615	40.1870	11.7325
1567	39.5853	11.6151	1616	40.1995	11.7349
1568	39.5979	11.6175	1617	40.2119	11.7373
1569	39.6106	11.6200	1618	40.2243	11.7397
1570	39.6232	11.6225	1619	40.2367	11.7421
1571	39.6358	11.6249	1620	40.2492	11.7446
1572	39.6484	11.6274	1621	40.2616	11.7470
1573	39.6610	11.6299	1622	40.2740	11.7494
1574	39.6736	11.6323	1623	40.2864	11.7518
1575	39.6862	11.6348	1624	40.2988	11.7542
1576	39.6988	11.6372	1625	40.3112	11.7566
1577	39.7114	11.6397	1626	40.3236	11.7590
1578	39.7240	11.6422	1627	40.3360	11.7614
1579	39.7366	11.6446	1628	40.3484	11.7639
1580	39.7492	11.6471	1629	40.3608	11.7663
1581	39.7617	11.6495	1630	40.3732	11.7687
1582	39.7743	11.6520	1631	40.3856	11.7711
1583	39.7869	11.6544	1632	40.3980	11.7735
1584	39.7994	11.6569	1633	40.4103	11.7759
1585	39.8120	11.6594	1634	40.4227	11.7783
1586	39.8246	11.6618	1635	40.4351	11.7807
1587	39.8371	11.6643	1636	40.4474	11.7831
1588	39.8497	11.6667	1637	40.4598	11.7855
1589	39.8622	11.6692	1638	40.4722	11.7879
1590	39.8748	11.6716	1639	40.4845	11.7903
1591	39.8873	11.6740	1640	40.4969	11.7927
1592	39.8998	11.6765	1641	40.5092	11.7951
1593	39.9124	11.6789	1642	40.5215	11.7975
1594	39.9249	11.6814	1643	40.5339	11.7999
1595	39.9374	11.6838	1644	40.5462	11.8023
1596	39.9499	11.6863	1645	40.5585	11.8047
1597	39.9624	11.6887	1646	40.5709	11.8071
1598	39.9749	11.6911	1647	40.5832	11.8094
1599	39.9874	11.6936	1648	40.5955	11.8118
1600	40.0000	11.6960	1649	40.6078	11.8142
1601	40.0124	11.6985	1650	40.6201	11.8166
1602	40.0249	11.7009	1651	40.6324	11.8190
1603	40.0374	11.7033	1652	40.6448	11.8214
1604	40.0499	11.7058	1653	40.6571	11.8238
1605	40.0624	11.7082	1654	40.6693	11.8261
1606	40.0749	11.7106	1655	40.6816	11.8285
1607	40.0874	11.7131	1656	40.6939	11.8309
1608	40.0998	11.7155	1657	40.7062	11.8333
1609	40.1123	11.7179	1658	40.7185	11.8357

Numb.	Square Roots.	Cube Roots.	Numb.	Square Roots.	Cube Roots.
1659	40.7308	11.8381	1694	41.1582	11.9207
1660	40.7430	11.8404	1695	41.1703	11.9231
1661	40.7553	11.8428	1696	41.1825	11.9254
1662	40.7676	11.8452	1697	41.1946	11.9278
1663	40.7798	11.8476	1698	41.2067	11.9301
1664	40.7921	11.8499	1699	41.2189	11.9324
1665	40.8044	11.8523	1700	41.2310	11.9348
1666	40.8166	11.8547	1701	41.2431	11.9371
1667	40.8289	11.8571	1702	41.2553	11.9395
1668	40.8411	11.8594	1703	41.2674	11.9418
1669	40.8533	11.8618	1704	41.2795	11.9441
1670	40.8656	11.8642	1705	41.2916	11.9465
1671	40.8778	11.8665	1706	41.3037	11.9488
1672	40.8900	11.8689	1707	41.3158	11.9511
1673	40.9023	11.8713	1708	41.3279	11.9535
1674	40.9145	11.8736	1709	41.3400	11.9558
1675	40.9267	11.8760	1710	41.3521	11.9581
1676	40.9389	11.8784	1711	41.3642	11.9605
1677	40.9511	11.8807	1712	41.3763	11.9628
1678	40.9633	11.8831	1713	41.3884	11.9651
1679	40 9756	11.8854	1714	41.4004	11.9675
1680	40.9878	11.8878	1715	41.4125	11.9698
1681	41.0000	11.8902	1716	41.4246	11 9721
1682	41.0121	11.8925	1717	41.4366	11.9744
1683	41.0243	11.8949	1718	41.4487	11.9768
1684	41.0365	11.8972	1719	41.4608	11 9791
1685	41.0487	11.8996	1720	41.4728	11.9814
1686	41.0609	11.9019	1721	41.4849	11.9837
1687	41.0731	11.9043	1722	41.4969	11.9860
1688	41.0852	11.9066	1723	41.5090	11.9884
1689	41.0974	11 9090	1724	41.5210	11.9907
1690	41.1096	11.9113	1725	41.5331	11.9930
1691	41.1217	11.9137	1726	41.5451	11.9953
1692	41.1339	11.9160	1727	41.5571	11.9976
1693	41.1460	11.9184	1728	41.5692	12.0000

To find the root of a number, consisting of integers and decimals.

RULE.—Multiply the difference between the root of the integer part of the given number, and the root of the next higher integer number, by the decimal part of the given number, and add the product to the root of the integer number given; the sum will be the root of the number required, correct in all cases of the square root to 3 places of decimals, and in the cube root to 7.

EXAMPLE 1.—Required the square root of 60.2.

$$
\begin{array}{lr}
\sqrt{61} = & 7.8102 \\
\sqrt{60} = & 7.7459 \\
\hline
\text{difference} & .0643 \\
\times & .2 \\
\hline
= & .01286 \\
+ & 7.7459 \\
\hline
\sqrt{60.2} = & 7.75876
\end{array}
$$

as required, correct to 3 places of decimals.

EXAMPLE 2.—Required the cube root of 843.75.

$$
\begin{array}{lr}
\sqrt[3]{844} = & 9.4503 \\
\sqrt[3]{843} = & 9.4466 \\
\hline
\text{difference} & .0037 \\
\times & .75 \\
\hline
= & .002775 \\
+ & 9.4466 \\
\hline
\sqrt[3]{843.75} = & 9.449375
\end{array}
$$

as required.

If the square root is required correct to more places of decimals, the following rule is correct to 7 places:

Multiply the root of the nearest integer number by twice the difference between that and the given number, and divide the product by 3 times the integer number added to the given number; and the quotient added to the root of the integer number will be the root of the given number nearly. Then, the root of 60.2 will stand thus,

$$
\begin{array}{l}
\sqrt{60} \quad 7.7459 \\
\qquad\quad \times \quad .4 \quad 2 \times 2 \\
\hline
60 \times 3 = 180 + 60.2 = 240.2)3.09836(.01289 + 7.7459 = 7.75889 \\
\qquad 2402 \qquad\qquad \text{the root required.} \\
\hline
\qquad 6963 \\
\qquad 4804 \\
\hline
\qquad 21596 \\
\qquad 19216 \\
\hline
\qquad\; 23800
\end{array}
$$

If the number consist wholly of decimals, the root will be decimals also.

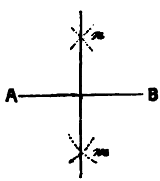
PRACTICAL GEOMETRY.

Practical Geometry is the art of describing mathematical figures by a ruler and compasses, or other instruments proper for the purpose.

PROBLEM I.

To divide a given line into two equal parts.

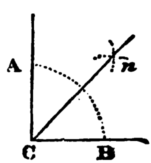
From A and B as centres, with any distance greater than half the length of the line, describe arcs cutting each other in *m* and *n*; then a line drawn through the points *m* and *n* will divide the line into two equal parts, as required.



PROBLEM II.

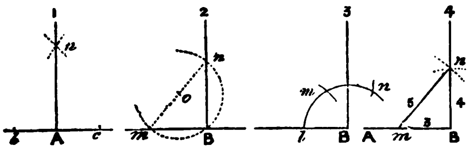
To divide a given angle into two equal parts.

From the point C as a centre, with any distance at pleasure, describe the arc A B; and from A and B as centres, with the same or any other convenient distance, describe arcs cutting each other in *n*; then a line drawn from the point C, through *n*, will divide the angle as required.



PROBLEM III.

From any given point in a right line, to erect a perpendicular.



1.—On each side of the point A, take equal distances, as *b* A, A *c*; from *b* and *c*, as centres, with any radius greater than *b* A or *c* A, describe arcs cutting each other in *n*; then will a line drawn from the point A through *n* be the perpendicular required.

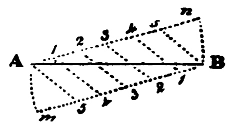
2.—With any radius from the point *o* as a centre, describe the arc *m* B *n*, cutting the line in *m* and B; draw a line from the point *m* through the centre *o* to *n*; then a line drawn through the point *n* to B is the perpendicular required.

3.—On the point B as a centre, with any radius, describe the arc *l m n*, cutting the line in *l*: with the same radius taking *m* and *n* as centres, describe arcs cutting each other in *r*; then a line drawn from B through *r* will be the perpendicular required.

4.—From the point B, on the line A B, take three equal parts (as feet, inches, &c.) to *m*; and from *m* and B as centres, describe arcs cutting each other in *n*, making the distance from B to *n* four parts, and from *m* to *n* five parts, then will the line B *n* be the perpendicular required.

PROBLEM IV.

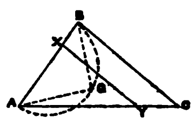
To divide a right line into any number of equal parts.



On each side of the given line make any angle with the line, as A B *m*, A B *n*; from each end of the line, and along the outside of each angle, with any distance, set off the proposed number of equal parts, as A, 1, 2, 3, &c.; B, 1, 2, 3, &c.; join the parts, as A 5; 1, 4; 2, 3, &c.; and the line A B will be divided as required.

PROBLEM V.

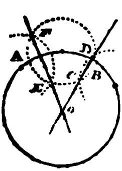
To divide a triangle into two equal parts, and still retain its original form.



Let A B C be the given triangle to be divided, bisect one of its sides as A B, and describe the semicircle A G B; bisect the semicircle in G, and at a distance from A, equal to A G or B G, draw the line, *x y*, parallel to B C, which is the line of equal division as required.

PROBLEM VI.

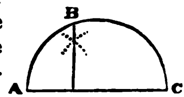
Through any three points out of a right line to describe the circumference of a circle.



From the middle point as a centre, with any convenient distance, describe the circle, or arcs of a circle, as A and B, and from the other points, with the same distance, describe arcs cutting the circle in C D and E F; draw lines through C D and E F, and where they intersect each other at *o* is the centre of the circle required.

PROBLEM VII.

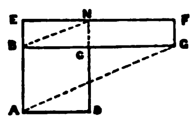
To find a mean proportional between two given right lines, or the side of a square equal to a given rectangle.



Upon a right line as a diameter equal to both given lines, describe the semicircle A B C, and where the two lines meet, or between their respective lengths, erect a perpendicular to the semicircle at B, and the perpendicular will be the mean proportion or side of the required square, equal to the given rectangle.

PROBLEM VIII.

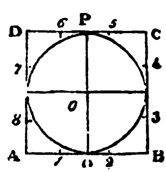
To produce a rectangle equal to a given square.



Suppose *a b c* and *d* be the given square, also *b e* one end of the required rectangle, draw *e f* parallel to *b c*, join *b n*, continue the side of the square *b c*, and draw the line *a g* parallel with *b n*, until it intersects at *g*, then *b g* is the side of the rectangle required.

PROBLEM IX.

To circumscribe a square about a given circle.

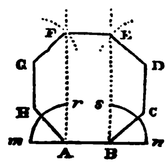


Draw two diameters at right angles as *m n* and O P; from *m n*, O P, as centres, with the radius of the circle, describe arcs cutting each other in A B C and D; join A B, B C, C D, D A, and A B C D will be the square required.

And from A as a centre, with the distance A *o*, cut the lines A B, A D, in 2 and 7; from B as a centre cut the lines B A, B C, in 1 and 4; from C as a centre cut the lines C B, C D, in 3 and 6; and from D as a centre cut the lines D C, D A, in 5 and 8; join 1, 8; 2, 3; 4, 5; and 6, 7; and 1, 2, 3, 4, 5, 6, 7, 8, will be a regular octagon.

PROBLEM X.

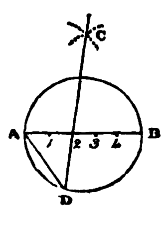
Upon a right line to describe an octagon.



On the extremities of one side A B, erect the perpendiculars A F and B E; continue the line A B to A *m* and B *n*, forming the angles A *m r*, and B *n s*; bisect the angles with the lines A H and B C; make each of those lines equal to A B; make H G and C D the same length, and parallel to A F and B E; from G and D as centres with the radius A B, describe arcs cutting A F and B E; join G F, F E, and E D, then A B C D E F G H will be the octagon required.

PROBLEM XI.

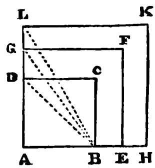
In a given circle to inscribe any regular polygon.



Divide the diameter A B into as many equal parts as the polygon is required to have sides; from A and B as centres, with the distance A B, describe arcs cutting each other in C; draw a line through the second division, meeting the circumference at D; join A D, and it will be the side of the polygon required.

PROBLEM XII.

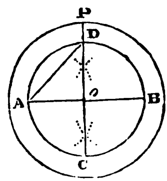
To find the side of a square that shall be any number of times the area of a given square.



Let A B C D be the given square, then will the diagonal B D be the side of a square A E F G, double in area to the given square A B C D; and if the diagonal be drawn from B to G, it will be the side of a square A H K L, three times the area of the square A B C D, or the diagonal B L will equal the side of a square four times the area of the square A B C D, &c.

PROBLEM XIII.

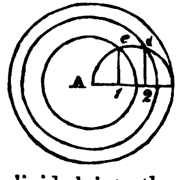
To find the diameter of a circle that shall be any number of times the area of a given circle.



Let A B C D be the given circle, draw the two diameters A B and C D at right angles to each other, and the chord A D will be the radius of the circle *o* P, twice the area of the given circle nearly; and half the chord will be the radius of a circle that will contain half the area, &c.

PROBLEM XIV.

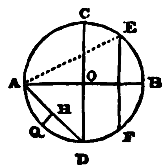
To divide a given circle into any number of co-centric parts equal to each other.



Upon the radius A B describe the semicircle A *e* *d* B; divide A B into the proposed number of equal parts, as 1, 2, &c.; erect the perpendiculars 1 *e*, 2 *d*, &c., meeting the semicircle in *e* and *d*; then from the centre A, and radii A *e* A *d*, &c., describe circles; so shall the circle be divided into the proposed number of equal parts, as required.

PROBLEM XV.

To find the side of a square nearly equal in area to a given circle.



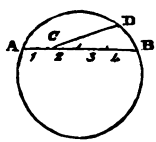
Draw the two diameters A B and C D at right angles to each other, bisect the radius O C by a line from one end of the diameter at A, meeting the circumference in E, then will the line A E be the side of a square nearly equal in area to the given circle.

And if the line E F be drawn parallel to C D, it will be $\frac{1}{4}$ of the circumference nearly.

Or three times the diameter A B or C D, and once the versed sine Q H, of the angle A O D, will be the circumference nearly.

PROBLEM XVI.

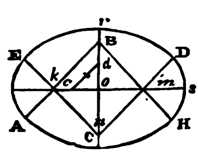
To find a right line that shall be nearly equal to any given arc of a circle.



Divide the chord A B into four equal parts, set one part on the circumference from B to D, draw a line from C, the first division on the chord; and twice the length of the line C D will be the length of the arc nearly.

PROBLEM XVII.

To describe an ellipsis, the transverse and conjugate diameters being given.

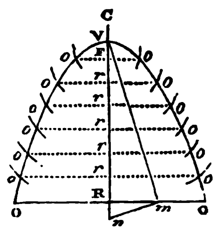


From *o*, as a centre, with the difference of the transverse and conjugate semi-diameters, set off *o c* and *o d;* draw the diagonal *c d*, and continue the line *o c* to *k*, by the addition of half the diagonal *c d*, then will the distance *o k* be the radius of

the centres that will describe the ellipsis; draw the lines A B, C D, C E, and B H, cutting the semi-diameters of the ellipsis in the centres *k l m n;* then with the radius *m s* describe the arcs D H and A E; also, with the radius *n r* describe the arcs E D and A H, which will be the ellipsis required.

PROBLEM XVIII.

To describe a parabola, any ordinate to the axe and its abscissa being given.



Let V R and R *o* be the given abscissa and ordinate; bisect R *o* in *m*, join V *m*, and draw *m n* perpendicular to it, meeting the axe in *n;* make V C and V F each equal to R *n*, then will F be the ocus of the curve.

Take any number of points, *r*, *r*, &c., in the axis, and draw the double ordinates of an indefinite length.

From F, as a centre, with the radii C F, C *r*, &c., describe arcs cutting the corresponding ordinates in the points *o o o o*, &c., and the curve *o* V *o*, drawn through all the points of intersection, will be the parabola required.

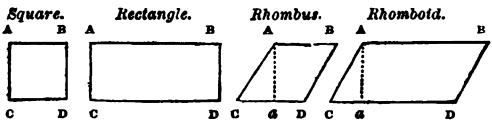
MENSURATION OF SUPERFICIES.

The area or superficial content of any figure is the space contained within length and breadth, without having any regard to the thickness.

PROBLEM I.

To find the area of any parallelogram, whether it be a square, a rectangle, a rhombus, or a rhomboid.

Rule.—Multiply the length by the breadth or height, and the product will be the area.



Example.—Required the area of a rhomboid whose length A B = 20.5, and breadth *a* A = 11.75.

$$20.5 \times 11.75 = 240.875 \text{ the area.}$$

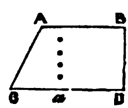
PROBLEM II.

To find the area of a trapezoid.

Rule.—Add together the two parallel sides, multiply their sum by the breadth or height, and half the product is the area.

Example.—Required the area of a trapezoid whose sides A B and C D are 14.5 and 10.25, and breadth, *a* A, = 7.25.

$$\frac{\overline{14.5 + 10.25} \times 7.25}{2} = 89.71875$$



the area.

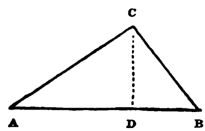
PROBLEM III.

To find the area of a triangle.

RULE.—Multiply one of its sides as a base by a perpendicular let fall from the opposite angle, and take half the product for the area.

Or, Subtract each side separately from half the sum of the sides, multiply the half sum of the sides by the three remainders, and the square root of the product will be the area.

EXAMPLE 1.—Required the area of a triangle A B C whose base A B = 16.5, and perpendicular D C = 10.25.



$$\frac{16.5 \times 10.25}{2} = 84.5625$$

the area.

EXAMPLE 2.—What is the area of that triangle whose three sides are 8, 12, and 16 respectively?

$\frac{8 + 12 + 16}{2} = 18$, the half sum of the sides;

then, 18 18 18
8 12 16
— — —
10 6 2 and $\sqrt{18 \times 10 \times 6 \times 2} = 46.47$

the area.

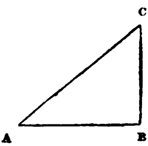
PROBLEM IV.

If any two sides of a right-angled triangle be given, the third side may be found by the following rules.

1.—To the square of the base add the square of the perpendicular; and the square root of the sum will be the hypotenuse or longest side.

2.—Multiply the sum of the hypotenuse, and one side by their difference; and the square root of the product will be the other side.

EXAMPLE 1.—Given the base A B = 16, and perpendicular B C = 12; required the length of the hypotenuse A C.



$\sqrt{16^2 + 12^2} = 20$ the length of the hypotenuse A C.

EXAMPLE 2.—Given the base A B = 16, and hypotenuse A C = 20; required the length of the perpendicular B C.

$\sqrt{\overline{20 + 16} \times 4} = 12$, length of the perpendicular B C.

NOTE.—The diagonal line, or hypotenuse in a square, is equal to the square root of twice the square of the side. And the side of a square is equal to the square root of half the square of its diagonal.

Thus, suppose each side of a square equal 12 feet:—

$12^2 \times 2 = \sqrt{288} = 16.9705$ feet, the diagonal. Or,

$\frac{16.9705^2}{2} = \sqrt{144} = 12$ feet, the length of each side.

PROBLEM V.

To find the area of any regular polygon.

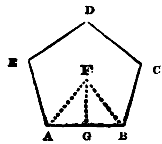
RULE.—Multiply the sum of its sides by a perpendicular drawn from its centre to one of its sides, and take half the product for the area.

Or, Multiply the square of the side of a polygon (from three to twelve sides) by the numbers in the fourth column of the table for polygons, opposite the number of sides required, and the product will be the area nearly.

EXAMPLE 1.—Required the area of the regular pen-

tagon A B C D E, each side being 7.5, and perpendicular F G = 6.4.

$$\frac{7.5 \times 5 \times 6.4}{2} = 120 \text{ the area.}$$



EXAMPLE 2.—What is the area of a regular hexagon, each side being 8.75 in length?

$8.75^2 \times 2.598 = 199.009375$ the area.

Table of multipliers for polygons from three to twelve sides.

Names.	*Sides.*	*Multipliers.*	*Multipliers.*	*Multipliers.*	*Areas.*
Trigon	3	2	1.73	.579	.433
Tetragon.....	4	1.41	1.412	.705	1.000
Pentagon.....	5	1.238	1.174	.852	1.72
Hexagon	6	1.156	= Radius.	= Length of side.	2.598
Heptagon...	7	1.11	.867	1.16	3.634
Octagon	8	1.08	.765	1.307	4.828
Nonagon......	9	1.062	.681	1.47	6.1818
Decagon......	10	1.05	.616	1.625	7.694
Undecagon...	11	1.04	.561	1.777	9.365
Dodecagon...	12	1.037	.515625	1.94	11.196

1.—*The breadth of a polygon given, to find the radius of a circle to contain that polygon.*

RULE.—Multiply half the breadth of the polygon by the numbers in the first column opposite to its name, or number of sides, and the product will be the radius of a circle to contain that polygon.

And if the polygon have an unequal number of sides, the half breadth is accounted from its centre to one of *its sides.*

2.—*The radius of a circle given, to find the length of side.*

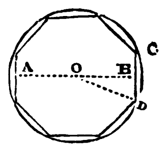
Rule.—Multiply the radius of any circle by the numbers in the second column opposite the polygon required; and the product will be the length of side nearly that will divide that circle into the proposed number of sides. And,

3.—*The length of side given, to find the radius.*

Rule.—Multiply the given length of side by the numbers in the third column opposite the polygon required; and the product will be the radius of a circle to contain that polygon.

Example 1.—Required the radius of a circle to contain an octagon, whose breadth A B = 18.5 inches.

Half of 18.5 = 9.25, and 9.25 × 1.08 = 9.99 or ten inches nearly, the radius of the circle O D.



Example 2.—Given the radius O D = 9.99 inches; required the length of side D C.

9.99 × 7.65 = 7.64235, the length of side.

Example 3.—Given the length of side D C = 7.64235; required the radius D O.

7.64235 × 1.307 = 9.98855145, or 9.99 in. nearly.

PROBLEM VI.

Having the diameter of a circle given, to find the circumference; or the circumference given, to find the diameter.

Rule 1.—As 7 is to 22, so is the diameter to the circumference.

Or, as 22 is to 7, so is the circumference to the diameter.

2.—As 1 is to 3.1416, so is the diameter to the circumference.

Or, as 3.1416 is to 1, so is the circumference to the diameter.

EXAMPLE 1.—Required the circumference of a circle when the diameter is 23.5.

$$\frac{23.5 \times 22}{7} = 73\tfrac{6}{7}, \text{ the circumference.}$$

EXAMPLE 2.—The circumference of a circle is $73\frac{6}{7}$, required the diameter.

$$\frac{73\frac{6}{7} \times 7}{22} = 23.5, \text{ the diameter.}$$

EXAMPLE 3.—Required the circumference of a circle whose diameter is 30.

$$3.1416 \times 30 = 94.248, \text{ the circumference.}$$

EXAMPLE 4.—What is the diameter of a circle when the circumference is 94,248 ?

$$94.248 \div 3.1416 = 30, \text{ the diameter.}$$

NOTE.—If the vessel is to be constructed with two ends, divide four times the required solidity by 3.1416, and the cube root of the quotient equal both length and diameter in equal terms.

Thus, $\frac{600 \times 4}{3.1416} = \sqrt[3]{764} = 9.142$ diameter and depth required.

PROBLEM VII.

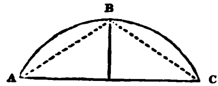
To find the length of any arc of a circle.

RULE.—Subtract the chord of the whole arc from eight times the chord of half the arc; and $\frac{1}{3}$ of the remainder is the length of the arc nearly.

EXAMPLE.—Required the length of the arc A B C;

the chord of half the arc A B = 19.8, and chord of the whole arc A C = 34.4.

$19.8 \times 8 = 158.4$ and $\frac{158.4 - 34.4}{3} = 41.33$, the length of the arc.



PROBLEM VIII.

To find the diameter of a circle, by having the chord and verse sine given.

RULE.—Divide the square of half the chord by the versed sine, to the quotient of which add the versed sine, and the sum will be the diameter.

Or, if the sum of the squares of the semichord and versed sine be divided by the versed sine, the quotient will be the diameter of the circle to which that segment corresponds.

EXAMPLE.—Given the chord A B = 24, and versed sine C D = 8; required the diameter of the circle C E.

Half the chord = 12 and $12^2 \div 8 = 18 + 8 = 26$, the diameter.

Or, $\frac{12^2 + 8^2}{8} = 26$, as before.

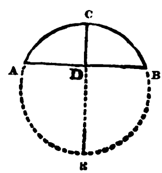


Table of versed sines, whereby to ascertain the diameters of circles corresponding to any segment or part of a circle having a chord of three feet.

Length of chord three feet.	Versed sine in inches.	Corresponding diameter in ft. and in.	Versed sine in inches.	Corresponding diameter in ft. and in.	Versed sine in inches.	Corresponding diameter in ft. and in.
	Inches.	Ft. & In.	Inches.	Ft. & In.	Inches.	Ft. & In.
	6	5 0	$2\frac{3}{4}$	10 0	$1\frac{1}{2}$	18 0
	$5\frac{5}{8}$	5 3	$2\frac{5}{8}\ \frac{1}{16}$	10 3	$1\frac{3}{8}\ \frac{3}{32}$	18 6
	$5\frac{1}{4}$ & $\frac{3}{32}$	5 6	$2\frac{5}{8}$	10 6	$1\frac{3}{8}\ \frac{1}{32}$	19 0
	$5\frac{1}{16}$	5 9	$2\frac{1}{2}\ \frac{1}{16}$	10 9	$1\frac{3}{8}$	19 6
	$4\frac{3}{4}\ \frac{3}{32}$	6 0	$2\frac{1}{2}$	11 0	$1\frac{1}{4}\ \frac{3}{32}$	20 0
	$4\frac{1}{2}\ \frac{3}{32}$	6 3	$2\frac{3}{8}\ \frac{1}{16}$	11 3	$1\frac{1}{4}\ \frac{1}{32}$	21 0
	$4\frac{3}{8}\ \frac{1}{32}$	6 6	$2\frac{3}{8}$	11 6	$1\frac{1}{4}$	22 0
	$4\frac{1}{8}\ \frac{3}{32}$	6 9	$2\frac{1}{4}\ \frac{3}{32}$	11 9	$1\frac{1}{8}\ \frac{1}{32}$	23 0
	$4\frac{1}{32}$	7 0	$2\frac{1}{4}\ \frac{1}{32}$	12 0	$1\frac{1}{8}$	24 0
	$3\frac{7}{8}\ \frac{1}{32}$	7 3	$2\frac{1}{8}\ \frac{1}{16}$	12 6	$1\frac{1}{16}$	25 0
	$3\frac{3}{4}$	7 6	$2\frac{3}{32}$	13 0	$1\frac{1}{32}$	26 0
	$3\frac{5}{8}\ \frac{1}{32}$	7 9	$2\frac{1}{32}$	13 6	1 inch.	27 0
	$3\frac{1}{2}$	8 0	$1\frac{7}{8}\ \frac{1}{16}$	14 0	$\frac{7}{8}\ \frac{3}{32}$	28 0
	$3\frac{3}{8}$	8 3	$1\frac{7}{8}$	14 6	$\frac{7}{8}\ \frac{1}{16}$	29 0
	$3\frac{1}{4}\ \frac{1}{32}$	8 6	$1\frac{3}{4}\ \frac{1}{16}$	15 0	$\frac{7}{8}\ \frac{1}{32}$	30 0
	$3\frac{1}{8}\ \frac{1}{32}$	8 9	$1\frac{3}{4}$	15 6	$\frac{3}{4}\ \frac{1}{32}$	35 0
	$3\frac{1}{16}$	9 0	$1\frac{5}{8}\ \frac{1}{16}$	16 0	$\frac{5}{8}\ \frac{1}{32}$	40 0
	3	9 3	$1\frac{5}{8}$	16 6	$\frac{1}{2}\ \frac{3}{32}$	45 0
	$2\frac{7}{8}$	9 6	$1\frac{1}{2}\ \frac{3}{32}$	17 0	$\frac{1}{2}\ \frac{1}{16}$	50 0
	$2\frac{3}{4}\ \frac{1}{16}$	9 9	$1\frac{1}{2}\ \frac{1}{16}$	17 6		

Table of the relative proportions of the circle, its equal and inscribed squares.

1. The	Diameter of a circle......	× .8862	= the side of an equal square.
2. „	Circumference	× .2821	
3. „	Diameter	× .7071	= the side of an inscribed square.
4. „	Circumference	× .2251	
5. „	Area	× .6366	= the content of an inscribed square.
6. „	Side of inscribed square	× 1.4142	= the diameter of a circumscribing circle.
7. „	Side of inscribed square	× 4.443	= the circumference of a circumscribing circle.
8. „	Side of a square............	× 1.128	= the diameter of an equal circle.
9. „	Side of a square............	× 3.545	= the circumference of an equal circle.

Examples illustrative of the preceding table.

EXAMPLE 1.—The diameter of a circle is 12.5; required the side of a square equal in area to the given circle.

$12.5 \times .8862 = 11.07750$, side of equal square.

Ex. 2.—The circumference of a circle being 53.4; required the side of a square equal in area.

$53.4 \times .2821 = 15.06414$, side of equal square.

Ex. 3.—The diameter of a circle being 18; required the side of the greatest square that can be inscribed therein.

$18 \times .7071 = 12.7278$, side of inscribed square.

Ex. 4.—The circumference of a circle is 86; required the side of inscribed square.

$86 \times .2251 = 19.3586$, side of inscribed square.

Ex. 5.—The area of a circle being 371.5; required the area of the greatest square that can be inscribed within the circle.

$371.5 \times .6366, = 236.49690$, area of the required square.

Ex. 6.—The side of a square being 19.375; required the diameter of its circumscribing circle.

$19.375 \times 1.4142 = 27.4001250$, diameter.

Ex. 7.—Required the circumference of a circle to circumscribe a square, each side being 19.375.

$19.375 \times 4.443 = 86.083125$, circumference of the circle required.

Ex. 8.—The side of a square being 13.5; required the diameter of a circle equal in area to the given square.

$13.5 \times 1.128 = 152,280$, diameter of the circle required.

Ex. 9.—The side of a square being 13.5; required the circumference of a circle equal in area to the given square.

$13.5 \times 3.545 = 47.8575$, circumference of the circle required.

Some of the properties of a circle.

1.—It is the most capacious of all plain figures, or contains the greatest area within the same perimeter or outline.

2.—The areas of circles are to each other as the squares of their diameters, or of their radii.

3.—Any circle whose diameter is double that of another, contains four times the area of the other.

4.—The area of a circle is equal to the area of a triangle whose base is equal to the circumference, and perpendicular equal to the radius.

5.—The area of a circle is equal to the rectangle of its radius, and a right line equal to half its circumference.

6.—The area of a circle is to the square of the diameter as .7854 to 1; or, multiply half the circumference by half the diameter, and the product will be the area.

Example 1.—Required the area of a circle, the diameter being 30.5.

$30.5^2 \times .7854 = 730.618350$, the area required.

Example 2.—What is the area of a circle when the diameter is 1?

In this case the circumference is 3.1416, half of which is 1.5708, and half of $1 = .5$; then $1.5708 \times .5 = .7854$, the area.

PROBLEM IX.

Having the area of a circle given, to find the diameter.

Rule.—As 355 is to 452, so is the area to the square of the diameter.

Or, Multiply the square root of the area by 1.12837, and the product will be the diameter.

Example.—Required the diameter of that circle whose area is 122.71875.

$$\sqrt{\frac{122.71875 \times 452}{355}} = 12.5 \text{ diameter.}$$

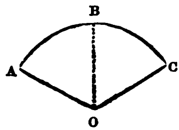
Or, $\sqrt{122.71875} = 11.077$; and $11.077 \times 1.12837 = 12.49895$, or 12.5 diameter.

PROBLEM X.

To find the area of a sector of a circle.

Rule.—Multiply the length of the arc by the radius of the circle, and half the product will be the area.

Example.—Required the area of a sector of a circle whose arc A B C = 26.666, and radius B O = 16.9,



$$\frac{26.666 \times 16.9}{2} = 225.3277$$

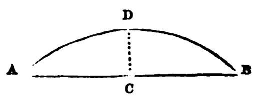
the area.

PROBLEM XI.

To find the area of a segment of a circle.

Rule.—Multiply the versed sine by the decimal .626, to the square of the product add the square of half the chord; multiply twice the square root of the sum by $\frac{2}{3}$ of the versed sine; and the product will be the area.

Example.—Required the area of a segment of a circle whose chord A B = 48, and versed sine C D = 18.



$18 \times .626 = 11.268^2 = 126.967824$; which add to 576, being the square of half the chord $= 702967824$, twice the square root of which is 53.026×12; being $\frac{2}{3}$ of the versed sine $= 636.312$ the area.

The following is a near approximate to the preceding rule:

To the cube of the versed sine, divided by twice the length of the chord, add $\frac{2}{3}$ of the product of the chord, multiplied by the versed sine; and the sum will be the area of the segment nearly. Take the last example:—

Versed sine = 18, and chord 48, then, $\frac{18^3}{48 \times 2} = 60.7$

And $\frac{48 \times 18 \times 2}{3} = 576 + 60.7 = 636.7$, the area nearly.

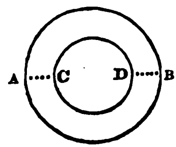
Or, the area of a segment may be found by finding the area of a sector having the same radius as the segment; then deducting the area of the triangle leaves the area of the segment.

PROBLEM XII.

To find the area of a circular ring or space included between two concentric circles.

RULE.—Add the inside and outside diameters together, multiply the sum by their difference, and by .7854; and the product will be the area.

EXAMPLE.—The diameters of two concentric circles, A B and C D, are 10 and 6; required the area of the ring or space contained between them.



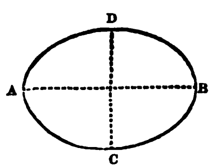
$\overline{10 + 6} \times 4 \times .7854 =$
50.2656 the area.

PROBLEM XIII.

To find the area of an ellipsis.

RULE.—Multiply the transverse or longer diameter by the conjugate or shorter diameter, and by .7854, and the product will be the area.

EXAMPLE.—Required the area of an ellipsis whose longer diameter A B = 12, and shorter diameter C D = 9.



$12 \times 9 \times .7854 =$
84.8232 the area.

NOTE.—If half the sum of the two diameters be multiplied by 3.1416, the product will be the circumference of the ellipsis

Thus, $12 + 9 = 21$, and $\frac{3.1416 \times 21}{2} = 36.1384$ the circumference.

MENSURATION OF SOLIDS.

By solids are meant all bodies, whether solid, fluid, or bounded space, that can be comprehended within length, breadth, and thickness.

PROBLEM I.

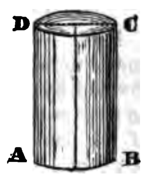
To find the convex surface and solid content of an upright cylinder.

RULE 1.—Multiply the circumference of the base by the height of the cylinder, and the product is the convex surface.

RULE 2.—Multiply the area of the base by the height of the cylinder, and the product is the solid content.

EXAMPLE 1.—Required the convex surface of the cylinder A B C D, whose base A B = 32 inches, and perpendicular height B C = 6 feet.

$3.1416 \times 32 \times 72$ inches = 7238.2464 square or superficial inches, and $7238.2464 \div 144 =$ 50.2658 superficial feet.



EXAMPLE 2.—Required the solid content, in cubic inches and cubic feet, of the cylinder as above.

$32^2 \times .7854 \times 72 = 57905.9712$ cubic inches, and $57905.9712 \div 1728 = 33.5104$ cubic feet.

EXAMPLE 3.—Suppose the cylinder A B C D be intended to contain a fluid, and that the sides and bottom are each one inch in thickness, how many imperial gallons would it contain?

$32 - 2 = 30$ inches diameter; and $72 - 1 = 71$ inches deep; then $\dfrac{30^2 \times .7854 \times 71}{277.274} =$ 181 gallons.

Or, $50187.06 \times .003607 = 181$, as before.

PROBLEM II.

To determine the dimensions of any cylindrical vessel, whereby to contain the greatest cubical contents, bounded by the least superficial surface.

RULE.—Multiply the given cubical contents by 2.56, and the cube root of the product equal the diameter, and half the diameter equal the depth.

EXAMPLE.—Suppose a cylindrical vessel is to be made so as to contain 600 cubic feet, and of such dimensions as to require the least possible materials by which it is constructed, what must be its depth and diameter?

$600 \times 2.56 = \sqrt[3]{1536} = 11.5379$ feet diameter, and $11.5379 \div 2 = 5.76895$ feet the depth.

NOTE.—If the vessel is to be constructed with two ends, then the cube root of four times the solidity divided by 3.1416 equal both the length and diameter, so as to expose the least possible surface, or be composed of the least possible materials, of which to be constructed.

PROBLEM III.

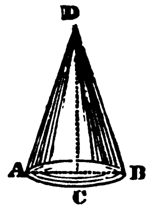
To find the surface and solid content of a cone or pyramid.

RULE 1.—Multiply the circumference of the base by the slant height, and half the product will be the slant surface, to which add the area of the base, and the product will be the whole surface.

RULE 2.—Multiply the area of the base by the per-

pendicular height, and $\frac{1}{3}$ of the product will be the solid content.

Example 1.—Required the convex surface of a cone whose base A B = 20 inches, and slant height B D = 29.5.



$$\frac{3.1416 \times 20 \times 29.5}{2} = 926.772$$

square inches, and divided by 144 = 6.435 superficial feet.

Example 2.—Required the solidity of the cone as above, the perpendicular C D being 28 inches.

$$\frac{20^2 \times .7854 \times 28}{3} = 2932.16 \text{ cubic inches, and}$$

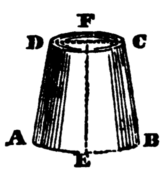
divided by 1728 = 1.697 cubic feet.

PROBLEM IV.

To find the surface of the frustum of a cone or pyramid.

Rule.—Multiply the sum of the perimeters of the two ends by the slant height, and half the product will be the slant surface; to which add the areas of the two ends, and the product will be the whole surface.

Example.—Required the convex surface of the frustum of a cone A B C D, whose base A B = 20 inches, the slant height B C = 19, and top end C D = 11.



$$\frac{\overline{3.1416 \times 20 + 3.1416 \times 11} \times 19}{2}$$

= 925,2012 square inches, and divided by 144 = 6.425 feet nearly.

PROBLEM V.

To find the solid content of the frustum of a cone.

Rule.—To the product of the diameters of the two ends, add the sum of their squares; multiply this sum by the perpendicular height and by .2618, the product is the solid content.

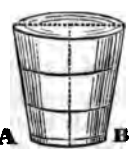
Example 1.—Required the solid content of the frustum in Problem IV, whose perpendicular E F = 18 inches.

$20 \times 11 = 220$, and $\overline{220 + 20^2 + 11^2} \times 18 \times .2618 = 3491.8884$ cubic inches, and divided by $1728 = 2.0208$ cubic feet nearly.

Example 2.—Required the content, in imperial gallons, of the inverted frustum of a cone A B C D, whose inner dimensions are $3\frac{1}{2}$ feet deep, 18 inches diameter at bottom, and 22 inches diameter at top.

$22 \times 18 = 396$ and $\overline{396 + 22^2 + 18^2} \times 42 \times .2618 = \dfrac{13238.7024}{277.274} =$ 47.745 gallons nearly.

Or, $13238,7024 \times 0.00360654 = 47.75$ gallons nearly, as before.



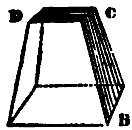
PROBLEM VI.

To find the solid content of the frustum of a pyramid.

Rule.—To the sum of the areas of the two ends add the square root of their product; multiply this sum by the perpendicular height, and $\frac{1}{3}$ of the product is the solid content.

Example.—Required the solid content of the frustum of a pyramid A B C D, whose perpendicular

height = 24 inches, the area of the base = 144 inches, and area of the top end = 64.



$144 + 64 = 208$ and $\sqrt{144 \times 64} = 96$, then $\frac{208 + 96 \times 24}{3} = 2432$ cubic inches, and $\div 1728 = 1.4074$ cubic feet nearly.

PROBLEM VII.

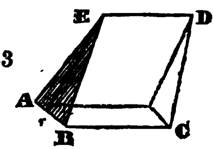
To find the solidity of a wedge.

Rule.—To the length of the wedge add twice the length of the base; multiply that sum by the height, and by the breadth of the base, and one-sixth of the product will be the solidity.

Example.—Required the content in cubic inches of the wedge A B C D E, whose base A B C = 12 inches long and 4 inches broad, the length of the edge D E = 10 inches, and perpendicular height r E = 20 inches.

$$\frac{\overline{10 + 24} \times 20 \times 4}{6} = 453.33$$

cubic inches.



PROBLEM VIII.

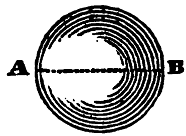
To find the convex surface and solid content of a sphere or globe.

Rule 1.—Multiply the square of the diameter by 3.1416, the product will be the convex superficies.

Rule 2.—Multiply the cube of the diameter by .5236, and the product is the solid content.

EXAMPLE 1.—Required the convex surface of a sphere, whose diameter A B = $25\frac{1}{2}$ inches.

$25.5^2 \times 3.1416 = 2042.8254$ square inches, $\div 144 = 14.1862$ square or superficial feet.



EXAMPLE 2.—Required the solid content of a sphere, whose diameter A B = $25\frac{1}{2}$ inches.

$25.5^3 \times .5236 = 8682.00795$ cubic inches, $\div 1728 = 5.0243$ cubic feet.

PROBLEM IX.

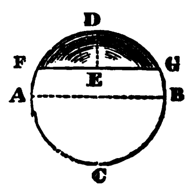
To find the convex surface and solid content of the segment of a sphere.

RULE 1.—Multiply the height of the segment by the whole circumference of the sphere, and the product is the curved surface.

RULE 2.—Add the square of the height to three times the square of the radius of the base; multiply that sum by the height, and by .5236, and the product is the solid content.

EXAMPLE 1.—The diameter A B of the sphere A B C D = 20 inches; what is the convex surface of that segment of it whose height E D = 8 inches?

$3.1416 \times 20 \times 8 = 502.656$ square inches $\div 144 = 3.49$ superficial feet.



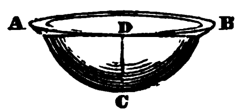
EXAMPLE 2.—The base F G of the segment F D G

= 18 inches, and perpendicular E D = 8, what is the solid content?

$8^2 = 64$, and $9^2 \times 3 = 243$, then $\overline{243 + 64} \times 8 \times .5236 = 1285.9616$ cubic inches $\div 1728 = .7441$ cubic feet.

Example 3.—Suppose A B C D to be a sugar pan, and that the diameter of the mouth A B is 4 feet, the depth D C being 25 inches, how many imperial gallons will it contain?

$25^2 = 625$, and $\overline{24^2 \times 3} = 1728$, then $\overline{1728 + 625} \times 25 \times .5236 = \dfrac{30800.77}{277.274}$ $= 111.084$ gallons



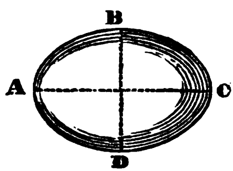
PROBLEM X.

To find the solidity of a spheroid.

Rule.—Multiply the square of the revolving axis by the fixed axis, and by .5236, and the product will be the solidity.

Example 1.—Required the solid content of the prolate spheroid A B C D, whose fixed axis A C is 50, and revolving axis B D 30

$30^2 \times 50 \times .5236 =$ 23562, the solidity.



Example 2.—What is the solid content of an oblate spheroid, the fixed axis being 30, and revolving axis 50?

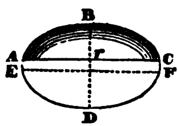
$50^2 \times 30 \times .5236 = 39270$, the solid content.

PROBLEM XI.

To find the solidity of the segment of a spheroid when the base is circular or parallel to the revolving axis.

RULE.—From triple the fixed axis take double the height of the segment; multiply the difference by the square of the height, and by .5236; then say, as the square of the fixed axis is to the square of the revolving axis, so is the former product to the solidity.

EXAMPLE 1.—Required the solid content of the segment A B C, whose height B r is 10; the revolving axis E F being 40, and fixed axis B D 25.



$\overline{25 \times 3} - \overline{10 \times 2} = 55$ and $55 \times 10^2 \times .5236 =$ 2879.8; then, as $25^2 : 40^2 :: 2879.8 : 7372.3$ nearly.

EXAMPLE 2.—What is the solid content of the segment of a spheroid whose height = 20 inches, the revolving axis being 25, and fixed axis 50?

$\overline{50 \times 3} - \overline{20 \times 2} = 110$, and $110 \times 20^2 \times .5236 = 23038.4$; then, as $50^2 : 25^2 :: 23038.4 : 5759.6$ inches, the solid content.

ROBLEM XII.

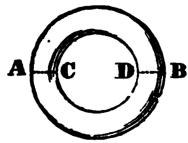
To find the convex surface and solid content of a cylindric ring.

RULE 1.—Multiply the thickness of the ring added to the inner diameter, by the thickness and by 9.8698, and the product will be the convex surface.

RULE 2.—To the thickness of the ring add the inner diameter; multiply that sum by the square of the thickness and by 2.4674, and the product will be the solid content.

EXAMPLE 1.—The thickness of a cylindric ring A C or D B $=$ 2 inches, and inner diameter $=$ 18, required the convex superficies.

$\overline{18 + 2} \times 2 \times 9.8698 =$ 394.792 square inches, and $\div$ 144 $=$ 2.741 superficial feet nearly.



EXAMPLE 2.—Required the solid content of the ring as above.

$18 + 2 \times 2^2 \times 2.4674 =$ 197.392 cubic inches and $\div$ 1728 $=$ .114 cubic feet.

NOTE.—A cubic foot is equal to 1728 cubic inches.
or 2200 cylindrical inches.
or 3300 spherical inches.
or 6600 conical inches.

Also, the cubic foot being considered unity, or 1,
A cylinder 1 foot diameter, and 1 foot in length $=$ .7854
A sphere 1 foot in diameter .... $=$ .5236
And a cone 1 foot diameter at the base and 1 foot in height .... $=$ .2619

OF TIMBER MEASURE.

Timber is chiefly estimated by the square or superficial foot of 144 inches, or cubic foot of 1728; the calculation of which is performed by duodecimals; that is, the foot or inch, &c., divided into 12 parts or divisions, thus:—

12 fourths make .... 1 third,
12 thirds ,, ... 1 second,
12 seconds ,, ... 1 inch,
12 inches ,, ... 1 foot.

And the several values arising are:—

Feet multiplied by feet give feet,
Feet multiplied by inches give inches,
Feet multiplied by seconds give seconds,
Inches muliplied by inches give seconds,
Inches multiplied by seconds give thirds,
Seconds multiplied by seconds give fourths, &c.

But this rule is more commonly called Cross Multiplication, on account of commencing with the left hand figure of the multiplier.

Rule 1.—Place the multiplier under the multiplicand, feet under feet, inches under inches, seconds under seconds, &c.

2.—Multiply each denomination of the length by the feet of the breadth, beginning at the lowest, and place each product under that denomination of the multiplicand from which it arises, always carrying one for every 12.

3.—Multiply by the inches, and set each product one place farther to the right hand.

4.—Then multiply by the seconds, and set each product another place toward the right hand, &c.

Thus proceed in like manner with all the other denominations, and their sum will be the content.

EXAMPLE 1.—Required the superficial content of a board 12 feet 6 inches long and 1 foot $5\frac{1}{2}$ inches broad.

	F.	I.	
	12	6	
Multiplied by	1	5	6
	12	6	
	5	2	6
		6	3
Feet	18	2	9

When the two ends of a board or plank are of different breadths, add the two breadths together, and multiply the length by half the sum.

EXAMPLE 2.—A plank that is 1 foot 4 inches broad at one end, $11\frac{1}{2}$ inches broad at the other, and 18 feet 9 inches long, what is its superficial content?

$$16 + 11\tfrac{1}{2} = 27\tfrac{1}{2} \div 2 = 13\tfrac{3}{4} \text{ inches.}$$

	F.	I.		
Then	18	9		
$13\frac{3}{4}$ inches =	1	1	9	
	18	9		
	1	6	9	
	1	2	0	9
Feet	21	5	9	9

Superficial measure by the Engineer's Slide Rule.

When the length is given in feet, and the breadth in inches, the gauge point is 12; but if the dimensions are all inches, the gauge point is 144.

RULE.—Set the breadth upon B to the gauge point upon A, and against the length upon A is the content in square feet upon B.

EXAMPLE 1.—Required the number of square feet contained in a board $11\frac{1}{2}$ inches broad and 18 feet long.

Set 11.5 upon B to 12 upon A; and against 18 upon A is 17.3 feet upon B.

The content of one board being found, the content of any number of the same dimensions may be found by setting 1 upon B to the content of the one found upon A; and against any number of boards upon B is the whole content upon A.

Find the content of 8 boards, each being 17.3 square feet.

Set 1 upon B to 17.3 upon A; and against 8 upon B is 138.4 feet upon A.

EXAMPLE 2.—If a board is 10 inches broad at one end, and 7 at the other, what must be its length to make a square foot?

$10 + 7 = 17, \div 2 = 8\frac{1}{2}$ inches. Set 8.5 upon B to 144 upon A; and against 1 upon B is 16.9 inches long upon A.

To find the solidity of timber.

The solid content of timber (according to custom) is found by multiplying the length by the square of the $\frac{1}{4}$ girth

EXAMPLE.—Required the content of a tree in cubic feet, whose girth in the middle is 84 inches, and length 25 feet 6 inches.

$84 \div 4 = 21$ inches $\frac{1}{4}$ girth.

	F.	I.	
and 21 inches =	1	9	
Multiplied by	1	9	
	1	9	
	1	3	9
=	3	0	9

	F.	I.		
Then	25	6		
Multiplied by	3	0	9	
	76	6		
	1	7	1	6
Feet	78	1	1	6

But a more expeditious method is obtained by means of the following

TABLE.

¼ Girt in Inches.	Area in Feet.	¼ Girt in Inches.	Area in Feet.	¼ Girt in Inches.	Area in Feet.
6	.250	12¼	1.042	19	2.506
6¼	.272	12½	1.085	19½	2.640
6½	.294	12¾	1.129	20	2.777
6¾	.317	13	1.174	20½	2.917
7	.340	13¼	1.219	21	3.062
7¼	.364	13½	1.265	21½	3.209
7½	.390	13¾	1.313	22	3.362
7¾	.417	14	1.361	22½	3.516
8	.444	14¼	1.410	23	3.673
8¼	.472	14½	1.460	23½	3.835
8½	.501	14¾	1.511	24	4.000
8¾	.531	15	1.562	24½	4.168
9	.562	15¼	1.615	25	4.340
9¼	.594	15½	1.668	25½	4.516
9½	.626	15¾	1.722	26	4.694
9¾	.659	16	1.777	26½	4.876
10	.694	16¼	1.833	27	5.062
10¼	.730	16½	1.890	27½	5.252
10½	.766	16¾	1.948	28	5.444
10¾	.803	17	2.006	28½	5.640
11	.840	17¼	2.066	29	5.840
11¼	.878	17½	2.126	29½	6.044
11½	.918	17¾	2.187	30	6.250
11¾	.959	18	2.250		
12	1.000	18½	2.376		

Rule.—Multiply the area corresponding to the ¼ girth in inches by the length of the timber in feet; and the product is the solidity in feet and decimal parts.

Example.—A piece of timber, 18 feet long and 14 inches square, how many cubic feet does it contain?

$$1.361 \times 18 = 24.498 \text{ cubic feet.}$$

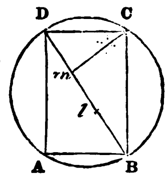
By the Slide Rule.

Set the length in feet upon B to 144 upon A; and against the square, or $\frac{1}{4}$ girth upon D, is the solid content in feet upon C.

EXAMPLE.—How many cubic feet is contained in a tree 28 feet long and 16 inches $\frac{1}{4}$ girth?

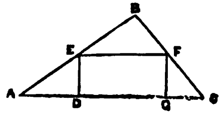
Set 28 upon B to 144 upon A; and against 16 upon D is 49.9 feet upon C.

To find the transverse section of the strongest beam that can possibly be cut out of a round piece of timber.



Let A B C D be the piece of timber given, draw the diameter B D, and divide it into three equal parts, as B l m D, erect the perpendicular m C, meeting the circle in C, draw D C and C B; then draw A B equal and parallel to D C, likewise A D equal and parallel to B C, and the rectangle will be a section of the beam, as required.

To determine the greatest rectangle that can possibly be obtained in a given triangle.



Let A B C be a given triangle, bisect any two of its sides, as E F; join E F, and to each end of which draw lines at right angles with the other side A C, and D E F G will be the rectangle required.

ON THE STRENGTH OF MATERIALS.

A knowledge of the strength of materials is one of the most important, and at the same time one of the most difficult subjects that the practical mechanic has to contend with, owing chiefly to the very different qualities of bodies of the same name; hence arise some doubts in selecting experiments whereon to build a data, there being scarcely two experiments made producing the same results. However, the following tables and rules are founded upon a mean of Messrs. Rennie, Barlow, and Telford's experiments, having found them to agree the best with practice, and my own experiments on similar bodies.

ON THE COHESIVE STRENGTH OF BODIES.

The cohesive strength of a body is that force with which it resists separation in the direction of its length, as in the case of ropes, &c.; and no reason can be assigned why the strength should not vary directly as the section of fracture, and is totally independent of the length in position, except so far as the weight of the body may increase the force applied: neglecting this, and supposing the body uniform in all its parts, the strength of bodies exposed to strains in the direction of their length, is directly proportionate to their transverse area, whatever be their figure, length, or position.

The following Table contains the result of experiments on the cohesive strength of various bodies in avoirdupois pounds;— also one-third of the ultimate strength of each body, this being considered sufficient, in most cases, for a permanent load.

Names of Bodies.	*Sq. Bar.*	*1 third.*	*Rnd. Bar.*	*1 third.*
WOODS.	*lbs.*	*lbs.*	*lbs.*	*lbs.*
Boxwood	20000	6667	15708	5236
Ash	17000	5667	13357	4452
Teak	15000	5000	11781	3927
Fir	12000	4000	9424	3141
Beech	11500	3866	9032	3011
Oak	11000	3667	8639	2880
METALS.				
Cast iron	18656	6219	14652	4884
English wrt. iron	55872	18624	43881	14627
Swedish do do.	72064	24021	56599	18866
Blistered steel	133152	44384	104577	34859
Shear do.	124400	41366	97703	32568
Cast do.	134256	44752	105454	35151
Cast copper	19072	6357	14979	4993
Wrought do.	33792	11264	26540	8847
Yellow brass	17968	5989	14112	4704
Cast tin	4736	1579	3719	1239
Cast lead	1824	608	1432	477

PROBLEM I.

To find the ultimate cohesive strength of square, round, and rectangular bars, of any of the various bodies, as specified in the table.

RULE.—Multiply the strength of an inch bar, (as in the table,) of the body required, by the cross sectional area of square and rectangular bars, or by the square of the diameter of round bars; and the product will be the ultimate cohesive strength.

EXAMPLE 1.—A bar of cast iron being $1\frac{1}{2}$ inches square, required its cohesive power.

$$1.5 \times 1.5 \times 18656 = 41976 \text{ lbs.}$$

Example 2.—Required the cohesive force of a bar of English wrought iron, 2 inches broad, and $\frac{3}{8}$ of an inch in thickness.

$$2 \times .375 \times 55872 = 41904 \text{ lbs.}$$

Example 3.—Required the ultimate cohesive strength of a round bar of wrought copper, $\frac{3}{4}$ of an inch in diameter.

$$.75^2 \times 26540 = 14928.75 \text{ lbs.}$$

PROBLEM II.

The weight of a body being given, to find the cross sectional dimensions of a bar or rod capable of sustaining that weight.

Rule.—For square and round bars,—Divide the weight given by one-third of the cohesive strength of an inch bar, (as specified in the table,) and the square root of the quotient will be the side of the square, or diameter of the bar in inches.

And if rectangular, divide the quotient by the breadth, and the result will be the thickness.

Example 1.—What must be the side of a square bar of Swedish iron to sustain a permanent weight of 18000 lbs ?

$$\sqrt{\frac{18000}{24021}} = .86, \text{ or nearly } \tfrac{7}{8} \text{ of an inch square.}$$

Example 2.—Required the diameter of a round rod of cast copper to carry a weight of 6800 lbs.

$$\sqrt{\frac{6800}{4993}} = 1.16 \text{ inches diameter.}$$

Example 3.—A bar of English wrought iron is to be applied to carry a weight of 2760 lbs ; required the thickness, the breadth being 2 inches.

$$\frac{2760}{18624} = .142 \div 2 = .071 \text{ of an inch in thickness.}$$

A TABLE

Showing the circumference of a rope equal to a chain made of iron of a given diameter, and the weight in tons that each is proved to carry; also the weight of a foot of chain made from iron of that dimension.

Ropes. Cir. in In.	*Chains. Dia. in Ins.*	*Proved to carry in tons.*	*Weight of a lineal foot in lbs. Avr.*
3	$\frac{1}{4}$ & $\frac{1}{16}$	1	1.08
4	$\frac{3}{8}$	2	1.5
$4\frac{3}{4}$	$\frac{3}{8}$ & $\frac{1}{16}$	3	2
$5\frac{1}{4}$	$\frac{1}{2}$	4	2.7
6	$\frac{1}{2}$ & $\frac{1}{16}$	5	3.3
$6\frac{1}{2}$	$\frac{5}{8}$	6	4
7	$\frac{5}{8}$ & $\frac{1}{16}$	8	4.6
$7\frac{1}{2}$	$\frac{3}{4}$	$9\frac{3}{4}$	5.5
8	$\frac{3}{4}$ & $\frac{1}{16}$	$11\frac{1}{4}$	6.1
9	$\frac{7}{8}$	13	7.2
$9\frac{1}{2}$	$\frac{7}{8}$ & $\frac{1}{16}$	15	8.4
$10\frac{1}{2}$	1 inch.	18	9.4

ON THE TRANSVERSE STRENGTH OF BODIES.

The *transverse strength* of a body is that power which it exerts in opposing any force acting in a perpendicular direction to its length, as in the case of beams, levers, &c., for the fundamental principles of which observe the following :—

That the transverse strength of beams, &c., is inversely as their lengths, and directly as their breadths, and square of their depths, and, if cylindrical, as the cubes of their diameters ; that is, if a beam 6 feet long, 2 inches broad, and 4 inches deep, can carry 2000 lbs., another beam of the same material, 12 feet long, 2 inches broad, and 4 inches deep, will only carry 1000, being inversely as their lengths. Again, if a beam 6 feet long, 2 inches broad, and 4 inches deep, can sup-

port a weight of 2000 lbs., another beam of the same material, 6 feet long, 4 inches broad, and 4 inches deep, will support double that weight, being directly as their breadths;—but a beam of that material, 6 feet long, 2 inches broad, and 8 inches deep, will sustain a weight of 8000 lbs.; being as the square of their depths.

From a mean of experiments made, to ascertain the transverse strength of various bodies, it appears that the ultimate strength of an inch square, and an inch round bar of each, 1 foot long, loaded in the middle, and lying loose at both ends, is nearly as follows, in lbs. avoirdupois.

Names of Bodies.	*Sq. Bar.*	*One-third.*	*Rnd. Bar.*	*One-third.*
Oak	800	267	628	209
Ash	1137	379	893	298
Elm	569	189	447	149
Pitch pine	916	305	719	239
Deal	566	188	444	148
Cast iron	2580	860	2026	675
Wrought iron	4013	1338	3152	1050

PROBLEM I.

To find the ultimate transverse strength of any rectangular beam, supported at both ends, and loaded in the middle; or supported in the middle, and loaded at both ends; also, when the weight is between the middle and the end; likewise, when fixed at one end and loaded at the other.

RULE.—Multiply the strength of an inch square bar, 1 foot long, (as in the table,) by the breadth, and square of the depth in inches, and divide the product by the length in feet; the quotient will be the weight in lbs. avoirdupois.

EXAMPLE 1.—What weight will break a beam of oak 4 inches broad, 8 inches deep, and 20 feet between the supports?

$$\frac{800 \times 4 \times 8^2}{20} = 10240 \text{ lbs.}$$

NOTE.—When a beam is supported in the middle and loaded at each end, it will bear the same weight as when supported at both ends and loaded in the middle, that is, each end will bear half the weight.

When the weight is not situated in the middle of the beam, but placed somewhere between the middle and the end,—Multiply twice the length of the long end by twice the length of the short end, and divide the product by the whole length of the beam: the quotient will be the effectual length.

EXAMPLE 2.—Required the ultimate transverse strength of a pitch pine plank, 24 feet long, 3 inches broad, 7 inches deep; and the weight placed 8 feet from one end.

$$\frac{32 \times 16}{24} = 21.3 \text{ effective length.}$$

and

$$\frac{916 \times 3 \times 7^2}{21.3} = 6321 \text{ lbs.}$$

Again, when a beam is fixed at one end and loaded at the other, it will only bear $\frac{1}{4}$ of the weight as when supported at both ends and loaded in the middle.

EXAMPLE 3.—What is the weight requisite to break a deal beam 6 inches broad, 9 inches deep, and projecting 12 feet from the wall?

$$\frac{566 \times 6 \times 9^2}{12} = 22923 \div 4 = 5730.7 \text{ lbs.}$$

The same rules apply as well to beams of a cylindrical form, with this exception, that the strength of a round bar (as in the table) is multiplied by the cube of the diameter, in place of the breadth, and square of the depth.

EXAMPLE 4.—Required the ultimate transverse strength of a solid cylinder of cast iron, 12 feet long, and 5 inches diameter.

$$\frac{2026 \times 5^3}{12} = 21104 \text{ lbs.}$$

EXAMPLE 5.—What is the ultimate transverse strength of a hollow shaft of cast iron, 12 feet long, 8 inches diameter outside, and containing the same cross sectional area as a solid cylinder 5 inches diameter?

$$\sqrt{8^2 - 5^2} = 6.24, \text{ and } 8^3 - 6.24^3 = 269.$$

$$\text{Then, } \frac{2026 \times 269}{12} = 45416 \text{ lbs.}$$

NOTE.—When a beam is fixed at both ends, and loaded in the middle, it will bear one-half more than it will when loose at both ends.

And if a beam is loose at both ends, and the weight laid uniformly along its length, it will bear double; but if fixed at both ends, and the weight laid uniformly along its length, it will bear triple the weight.

PROBLEM II.

To find the breadth or depth of beams intended to support a permanent weight.

RULE.—Multiply the length between the supports, in feet, by the weight to be supported in lbs., and divide the product by one-third of the ultimate strength of an inch bar, *(as in the table,)* multiplied by the square of the depth; the quotient will be the breadth, or, multiplied by the breadth, the quotient will be the square of the depth, both in inches.

EXAMPLE 1.—Required the breadth of a cast iron beam, 16 feet long, 7 inches deep, and to support a weight of 4 tons in the middle.

$$4 \text{ tons} = 8960 \text{ lbs. and}$$

$$\frac{8960 \times 16}{860 \times 7^2} = 3.4 \text{ inches.}$$

Example 2.—What must be the depth of a cast iron beam 3.4 inches broad, 16 feet long, and to bear a permanent weight of four tons in the middle?

$$\sqrt{\frac{8960 \times 16}{860 \times 3.4}} = 7 \text{ inches.}$$

Note 1.—When a beam is fixed at both ends, the divisor must be multiplied by 1.5, on account of it being capable of bearing one-half more.

2.—When a beam is loaded uniformly throughout, and loose at both ends, the divisor must be multiplied by 2, because it will bear double the weight.

3.—If a beam is fast at both ends, and loaded uniformly throughout, the divisor must be multiplied by 3, on account that it will bear triple the weight.

Example 3.—Required the breadth of an oak beam, 20 feet long, 12 inches deep, made fast at both ends, and to be capable of supporting a weight of 12 tons in the middle.

12 tons = 26880 lbs. and

$$\frac{26880 \times 20}{266 \times 12^2 \times 1.5} = 9.7 \text{ inches.}$$

Again, when a beam is fixed at one end, and loaded at the other, the divisor must be multiplied by .25; because it will only bear one-fourth of the weight,

Example 4.—Required the depth of a beam of ash, 6 inches broad, 9 feet projecting from the wall, and to carry a weight of 47 cwt.

47 cwt. = 5264 lbs. and

$$\sqrt{\frac{5264 \times 9}{379 \times 6 \times .25}} = 9.12 \text{ inches deep.}$$

And when the weight is not placed in the middle of a beam, the effective length must be found as in Problem I.

Example 5.—Required the depth of a deal beam

20 feet long, and to support a weight of 63 cwt. 6 feet from one end.

$$\frac{28 \times 12}{20} = 16.8 \text{ effective length of beam, and}$$

$$63 \text{ cwt.} = 7056 \text{ lbs. hence}$$

$$\sqrt{\frac{7056 \times 16.8}{188 \times 6}} = 10.24 \text{ inches deep.}$$

Beams or shafts exposed to lateral pressure are subject to all the foregoing rules, but in the case of water-wheel shafts, &c., some allowances must be made for wear, then the divisor may be changed from 675 to 600 for cast iron.

Example 6.—Required the diameter of bearings for a water-wheel shaft 12 feet long, to carry a weight of 10 tons in the middle.

$$10 \text{ tons} = 22400 \text{ lbs., and}$$

$$\frac{22400}{600} = \sqrt[3]{448} = 7.65 \text{ inches diameter.}$$

And when the weight is equally distributed along its length, the cube root of half the quotient will be the diameter, thus:

$$\frac{448}{2} = \sqrt[3]{224} = 6.07 \text{ inches diameter.}$$

Example 7.—Required the diameter of a solid cylinder of cast iron, for the shaft of a crane, to be capable of sustaining a weight of 10 tons; one end of the shaft to be made fast in the ground, the other to project $6\frac{1}{2}$ feet; and the effective leverage of the jib as $1\frac{3}{4}$ to 1.

$$10 \text{ tons} = 22400 \text{ lbs., and}$$

$$\frac{22400 \times 6.5 \times 1.75}{675 \times .25} = 1509$$

And $\sqrt[3]{1509} = 11.47$ inches diameter.

The strength of cast iron to wrought iron, in this direction, is as 9 is to 14 nearly; hence, if wrought iron is taken in place of cast iron in the last example, what must be its diameter?

$$\sqrt[3]{\frac{1509 \times 9}{14}} = 9.89 \text{ inches diameter.}$$

ON TORSION OR TWISTING.

The strength of bodies to resist *torsion*, or wrenching asunder, is directly as the cubes of their diameters; or, if square, as the cube of one side; and inversely as the force applied multiplied into the length of the lever.

Hence the rule.—1. Multiply the strength of an inch bar, by experiment, (*as in the following table,*) by the cube of the diameter, or of one side in inches; and divide by the radius of the wheel, or length of the lever also in inches; and the quotient will be the ultimate strength of the shaft or bar, in lbs. avoirdupois.

2.—Multiply the force applied in pounds by the length of the lever in inches, and divide the product by one-third of the ultimate strength of an inch bar, (*as in the table,*) and the cube root of the quotient will be the diameter, or side of a square bar in inches; that is, capable of resisting that force permanently.

The following Table contains the result of experiments on inch bars, of various metals, in lbs. avoirdupois.

Names of Bodies.	*Rd. Bar.*	*1 third.*	*Sq. Bar.*	*1 third.*
Cast iron...........	11943	3981	15206	5069
English wrt. iron.	12063	4021	15360	5120
Swedish do. do....	11400	3800	14592	4864
Blistered steel ...	20025	6675	25497	8499
Shear do............	20508	6836	26112	8704
Cast do.	21111	7037	26880	8960
Yellow brass...	5549	1850	7065	2355
Cast copper	4825	1608	6144	2048
Tin..................	1688	563	2150	717
Lead	1206	402	1536	512

EXAMPLE 1.—What weight, applied on the end of a 5 feet lever, will wrench asunder a 3 inch round bar of cast iron?

$$\frac{11943 \times 3^3}{60} = 5374 \text{ lbs. avoirdupois.}$$

EXAMPLE 2.—Required the side of a square bar of wrought iron, capable of resisting the twist of 600 lbs. on the end of a lever 8 feet long.

$$\sqrt[3]{\frac{600 \times 96}{5120}} = 2\tfrac{1}{4} \text{ inches.}$$

In the case of revolving shafts for machinery, &c., the strength is directly as the cubes of their diameters, and revolutions, and inversely as the resistance they have to overcome; hence,

From *practice*, we find that a 40-horse power steam-engine, making 25 revolutions per minute, requires a shaft (*if made of wrought iron*) to be 8 inches diameter: now the cube of 8, multiplied by 25, and divided by 40 = 320; which serves as a constant multiplier for all others in the same proportion.

EXAMPLE 3.—What must be the diameter of a wrought iron shaft for an engine of 65-horse power, making 23 revolutions per minute?

$$\sqrt[3]{\frac{65 \times 320}{23}} = 9.67 \text{ inches diameter.}$$

Mr. Robertson Buchanan, in his Essay on Shafts, gives 400 as a constant multiplier for cast iron shafts that are intended for first movers in machinery;

200 for second movers; and

100 for shafts connecting smaller machinery, &c.

EXAMPLE 1.—The velocity of a 30-horse power steam-engine is intended to be 19 revolutions per

minute. Required the diameter of bearings for the fly wheel shaft.

$$\sqrt[3]{\frac{400 \times 30}{19}} = 8.579 \text{ inches diameter.}$$

EXAMPLE 2.—Required the diameter of the bearings of shafts, as second movers from a 30-horse engine; their velocity being 36 revolutions per minute.

$$\sqrt[3]{\frac{200 \times 30}{36}} = 5.5 \text{ inches diameter.}$$

NOTE.—When shafting is intended to be of wrought iron, use 160 as the multiplier for second movers; and 80 for shafts connecting smaller machinery.

TABLE

Of the proportionate length of bearings, or journals for shafts of various diameters.

Dia. in Inches.	*Len. in Inches.*	*Dia. in Inches.*	*Len. in Inches.*
1	1¾	6½	¾
1½	2¼	7	9⅜
2	3	7½	10
2¼	3¼	8	10¾
2½	3½	8½	11⅜
3	4¼	9	12
3½	4⅞	9½	12¾
4	5⅛	10	13¼
4½	6⅛	10½	14
5	6¾	11	14½
5½	7⅛	11½	15¼
6	8¼	12	16

OF THE MECHANICAL POWERS.

When power is applied to overcome weight, or force to overcome resistance, the machines employed are called mechanic powers; and the application of such, the science of mechanics.

The power and weight are said to balance each other, or to be in equilibrio, when the effort of the one to produce motion in one direction is equal to the effort of the other to produce it in an opposite direction; or when the weight opposes that degree of resistance which is precisely required to destroy the action of the power.

The momentum or quantity of force of any moving body is the result of the quantity of matter multiplied by the velocity by which it is moved; and when the product arising from the multiplication of the particular quantities of matter in any two bodies by their respective velocities are equal, their momentum will be so too.

And it holds universally true, that when two bodies are suspended upon any machine, so as to act contrary to each other, if the machine be put in motion, and the perpendicular ascent of one body, multiplied into its weight, be equal to the perpendicular descent of the other, multiplied into its weight, those bodies, however unequal they may be in weight, will balance each other in all situations; for as the whole ascent of the one is performed in the same time as the whole descent of the other, their respective velocities must be as the spaces they move through; and the excess of weight in the one is compensated by the excess of velocity in the other. Upon this principle it is easy to compute the power of any machine, either simple or compound; for it is only finding how much swifter the power moves than the weight; and just so much is the power increased by the help of the machine.

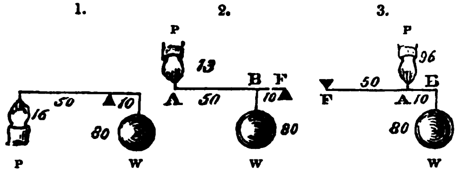
The simple machines, usually called mechanic powers, are six in number, namely, the Lever, the Wheel and Axle, the Pulley, the Inclined Plane, the Wedge, and the Screw.

There are three kinds of levers, caused by the different situations of the weights, props, and powers.

1.—When the weight is at one end, the power at the other, and the prop somewhere between.

2.—When the prop is at one end, the power at the other, and the weight between. And,

3.—When the prop is at one end, the weight at the other, and the power between. Thus,



In the first and second kind, the advantage gained is as the distance of the power from the prop, to the distance of the weight from the prop.

In the third kind, that there may be a balance between the power and the weight, the intensity of the power must exceed the intensity of the weight, just as much as the distance of the weight from the prop exceeds the distance of the power from the prop, that is, $P \times AF = W \times BF$; or the power and weight are reciprocally as the distances at which they act.

Or, in other words, Multiply the weight given by the distance from the prop, and divide by the distance from the power; the quotient will be the power or weight required.

EXAMPLES 1, 2, and 3.

Required the power necessary to counterpoise a weight of 80 lbs. on each of the three levers, whose lengths

are 60 inches, and in the first and second 10 inches from weight to prop, the third being 10 inches from weight to power.

First.... $\frac{80 \times 10}{50} = 16$ lbs. power.

Second.. $\frac{80 \times 10}{60} = 13.33$ lbs. power.

.Third... $\frac{80 \times 60}{50} = 96$ lbs. power.

Example 4.—What power is necessary to raise a weight of 620 lbs. by a lever of the first order, 72 inches long, and the prop placed 12 inches from the weight?

$72 - 12 = 60$ inches to power.

Then $\frac{620 \times 12}{60} = 124$ lbs.

Example 5.—A weight of 620 lbs. is to be lifted by a power of 124 lbs. applied to the end of a lever of the first order, 72 inches long; required at what distance from the weight the prop must be placed.

$$\frac{124 \times 72}{620 + 124} = 12 \text{ inches.}$$

Example 6.—A beam 20 feet long, and supported at both ends, bears a weight of 73 cwt. 4 feet 6 inches from one end; required the proportion of weight upon each support.

$\frac{73 \times 4.5}{20} = 16.425$ cwt. on the furthest support.

And $\frac{73 \times 15.5}{20} = 56.675$ cwt. on the nearest support.

Example 7.—A weight of 300 lbs. is fixed on the end of a lever 6 feet long; required the power, applied $2\frac{1}{2}$ feet from the prop, to raise the weight.

$$\frac{300 \times 6}{2.5} = 720 \text{ lbs. power.}$$

WHEEL AND AXLE.

Here the velocity of the power is to the velocity of the weight as the circumference of the wheel is to the circumference of the axle; hence, Divide the velocity of the power by the velocity of the weight, and the quotient is the weight that the power is equal to.

EXAMPLE 1.—A power equal to 30 lbs. is applied to the winch of a crane whose length is 15 inches; the pinion contains 10 teeth, the wheel 120, and the barrel is 9 inches diameter; required the weight raised.

$15 \times 2 \times 3.1416 = 94.248$ circumference of the circle described by the winch, or handle, $120 \div 10 = 12$ revolutions of the pinion for one of the wheel, and $3.1416 \times 9 = 28.2744$ the barrel's circumference; then,

$$\frac{94.248 \times 12 \times 30}{28.2744} = 1200 \text{ lbs. raised by this crane.}$$

EXAMPLE 2.—What would be the increase of power, in the last example, if a wheel of 150 teeth, and a pinion of 15, were added to the crane?

$150 \div 15 = 10$, that is, the velocity of the weight is diminished, while the velocity of the power is the same; then,

$$\frac{94.248 \times 12 \times 10 \times 30}{28.2744} = 12000 \text{ lbs. raised,}$$

the power being increased ten times.

EXAMPLE 3.—What power is requisite to raise 42 tons 60 feet high in 10 minutes, the velocity of the power being twenty feet per minute?

$$60 \div 10 = 6, \text{ and } \frac{\surd 42 \times 6}{20} = 12.6 \text{ tons power.}$$

TO CALCULATE FOR THE DIFFERENT PARTS OF A CRANE, AS RESPECTS MECHANICAL ADVANTAGE.

1. *The number of revolutions of the pinion to one of the wheel, the length of the handle, and the force applied given, to find the diameter of the barrel.*

RULE.—Multiply the diameter of the circle described by the winch, or handle, in inches, by the power applied in lbs., and by the number of revolutions of the pinion to one of the wheel; divide the product by the weight to be raised in lbs., and the quotient is the barrel's diameter in inches.

EXAMPLE.—Suppose that two men were required to raise a weight of one ton, by a crane, and each man to exert a constant force of $33\frac{1}{2}$ lbs. on a handle 16 inches long, the pinion making seven revolutions for one of the wheel, what must be the barrel's diameter?

$16 \times 2 = 32$ inches, diameter of the circle described by the handle, and $33\frac{1}{2} \times 2 = 67$ lbs. constant force; then,

$$\frac{32 \times 67 \times 7}{2240} = 6.7 \text{ inches.}$$

2.—*The diameter of the barrel, the length of the handle, and force applied given, to find the number of revolutions of the pinion to one of the wheel.*

RULE.—Multiply the weight to be raised in lbs. by the diameter of the barrel in inches, and divide the product by the diameter of the circle described by the handle in inches, multiplied by the power applied in lbs., and the quotient is the revolutions of the pinion to one of the wheel.

EXAMPLE.—What must be the number of revolutions of the pinion to one of the wheel, when the power applied is 67 lbs., the length of the handle 16 inches,

and the barrel 6.7 inches diameter, to counterpoise a weight of one ton, or 2240 lbs.?

$$\frac{2240 \times 6.7}{32 \times 67} = 7 \text{ revolutions to one of the wheel.}$$

3.—*The diameter of the barrel, the number of revolutions of the pinion to one of the wheel, and the power applied given, to find the length of the handles.*

RULE.—Multiply the weight to be raised in lbs. by the barrel's diameter in inches, and divide the product by the power applied in lbs., multiplied by the number of revolutions of the pinion to one of the wheel, and half the quotient is the length of the handles.

EXAMPLE.—It is estimated that the united effort of two men at the handles of a crane is 67 lbs. nearly; now a crane having a barrel of 6.7 inches diameter, and a pinion 7 to 1 of the wheel, what must be the length of handles to raise a weight of 1 ton?

$$\frac{2240 \times 6.7}{67 \times 7} = \frac{32}{2} = 16 \text{ inches.}$$

4.—*The diameter of the barrel, the revolutions of the pinion to one of the wheel, and length of handles given, to find the power required.*

RULE.—Multiply the weight to be raised in lbs. by the diameter of the barrel in inches, and divide the product by the diameter of the circle described by the handle, multiplied by the revolutions of the pinion to one of the wheel, and the quotient is the power required.

EXAMPLE.—What power will be required to raise one ton by a crane, whose barrel is 6.7 inches diameter, the pinion 7 to 1 of the wheel, and each handle 16 inches long?

$$\frac{2240 \times 6.7}{32 \times 7} = 67 \text{ lbs. power.}$$

NOTE.—The handles of a crane ought not to be less than 2 feet 11 inches, or 3 feet from the ground, and the jib to stand at an angle of about 45 degrees.

To find the thickness of cast iron for a crane post, when fixed at one end, and loaded at the other.

Rule.—Multiply the weight that the crane is to lift in lbs. by the leverage of the jib to one of the post, and by the length of the post in feet; divide the product by 168, then subtract the quotient from the cube of the outside diameter, and the cube root of the difference is the inside diameter.

Example.—What thickness must the metal be for a crane post to carry a weight of ten tons, the diameter of the post being 16 inches, and projecting 6 feet from the ground, the leverage of the jib being as $3\frac{1}{2}$ to 1 of the post?

$$10 \text{ tons} = 22400 \text{ lbs.}; \text{ then,}$$

$$\frac{22400 \times 3.5 \times 6}{168} = 2800$$

$$\text{the cube of } 16 = 4096, \text{ and}$$

$$4096 - 2800 = \sqrt[3]{1296} = 10.9$$

$$16 - 10.9 = \frac{5.1}{2} = 2\tfrac{1}{2} \text{ inches in thickness.}$$

THE PULLEY.

A single pulley, that only turns on its axis, and does not move out of its place, serves only to change the direction of the power, but gives no mechanical advantage. The advantage gained is always as twice the number of moveable pulleys, without taking any notice of the fixed pulleys necessary to compose the system of pulleys; hence, Divide the weight to be raised by twice the number of moveable pulleys, and the quotient is the power required to raise the weight, in terms of the same name.

Example 1.—What power is requisite to raise 250 lbs. with a pair of four-shieved blocks, the one block moveable and the other fixed?

$$4 \times 2 = 8, \text{ and } \frac{250}{8} = 31.25 \text{ lbs. power.}$$

EXAMPLE 2.—What weight will a power of 120 lbs. raise, when applied to a three and four-shieved block, the three being moveable and the other fixed?

$3 \times 2 = 6$, and $120 \times 6 = 720$ lbs. raised.

THE INCLINED PLANE.

The advantage gained by the inclined plane is as great as its length exceeds its perpendicular height; hence, when the power acts parallel to the plane, the length of the plane is to the weight as the height of the plane is to the power,—or, in other words, multiply the weight by the perpendicular height of the plane, and divide by its length, the quotient is the power that will support that weight upon the plane.

EXAMPLE 1.—Required the power, or equivalent weight, capable of supporting a load of 300 lbs. upou an inclined plane 50 feet long and 16 feet high.

50 is to 16 as 300 is to 96,

$$\text{Or, } \frac{300 \times 16}{50} = 96 \text{ lbs. power.}$$

EXAMPLE 2.—A power of 120 lbs., with a velocity of 50 feet per minute, is to be applied to move a weight up an inclined plane at the rate of 30 feet per minute; the plane is 25 feet long and 8 feet high; required the weight that the power is equal to.

$120 \times 50 = 6000$, and $30 \times 8 = 240$; then,

As $240 : 25 :: 6000 : 625$ lbs.

The weight multiplied by the length of the base, and divided by the length of the plane, equal the pressure on the plane.

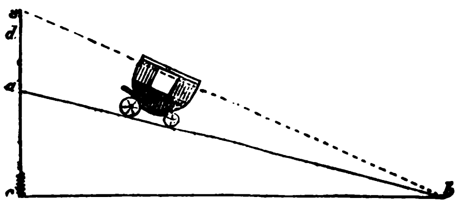
The space which a body describes upon an inclined plane, when descending by the force of gravity, is to the space which it would fall freely in the same time,

as the height is to the length of the plane, and the spaces being the same, the times will be inversely in this proportion.

Again, if two bodies descend from rest down two planes, equally inclined to the horizon, and then, without any loss of velocity, proceed to descend down two other inclined planes, also equally inclined to the horizon, the lengths of which are to each other in the same proportion as the lengths of the first two planes, the squares of the times of their whole motion will be in the same proportion as the lengths of the planes.

Means of ascertaining practically the effect produced by inclined planes.

Provide a board or box, *a b*, capable of holding pebbles, sand, &c., and which by a screw, *c*, can be easily raised at one end, as *a d s*, &c.



When *a b* lies flat on *c b*, the carriage will be at rest; but by the screw at *c* raising *a b* leisurely, the carriage will, at a certain height, set off by itself, and run down the plane. Then are we in possession of a triangle that solves what force is necessary to drag any load of any kind on a road or level ground; for the hypotenuse *a b* represents the weight of the carriage, and the perpendicular *a c* what portion of that weight is necessary to draw the carriage on level ground, thus,

Suppose the carriage	12 cwt.
The line *a b*.............	24 feet.
Height *c a*	3 feet.

The declivity, then, is as 3 to 24, or $\frac{1}{8}$. In this case it will be found that $\frac{1}{8}$ of the weight of the carriage would drag it on such a road or level ground, namely, $1\frac{1}{2}$ cwt.; but if the road were very deep and rough, it might require to be raised perhaps as high as *d* or *s*, before the carriage would set off. Now, if *c s* were half the length of *s b*, then it would require one-half the weight of the carriage to drag it on level ground, or, in the above case, 6 cwt.

This rule is universal, and has been proved by carriages at large, on roads of every description.

In estimating the draft up hill, the draft on the level must be added to it. Suppose the hill rises 1 foot in 4, then $\frac{1}{4}$ part of the weight must be added to the draft on level ground.

If the weight be, as before, 12 cwt., then $\frac{1}{4}$ would be 3 cwt.; and if its draft on a level were $1\frac{1}{2}$ cwt., then $4\frac{1}{2}$ cwt. would be the real draft necessary to draw 12 cwt. up a hill rising 1 foot in 4, &c.

EXAMPLE.—Suppose I find that, on an edge railway, a loaded carriage will just move by itself when there is a descent of $3\frac{1}{2}$ inches per chain, or about one perpendicular for 224 horizontal, which is (reckoning the carriage to weigh 1 ton) 10lbs. required to move it on a level. Now, from the above data, what force will be required to drag the same weight up a similar road ascending 1 inch per yard, or $\frac{1}{36}$? $\frac{1}{36}$ of a ton is $62\frac{2}{10}$ lbs., which added to 10 lbs. as above, amounts to $72\frac{2}{10}$ lbs., the weight required to drag it up an ascent of $\frac{1}{36}$; and allowing the strength of an ordinary horse to be 140 lbs., he will only be able to drag $1\frac{9}{10}$, or say 2 tons up an ascending plane of 1 in 36.

THE WEDGE.

As the wedge is seldom used without being driven, the force of the blow is not easily ascertained; of course, in practice it is not worth taking into account with respect to calculation.

THE SCREW.

The advantage gained by the screw is as much as the circumference of a circle, described by the lever or handle, exceeds the interval or distance between the spirals of the screw; hence, as the circumference of the circle described by the handle is to the pitch of the screw, so is the weight to the power.

EXAMPLE.—What power is necessary to raise a weight of 6000 lbs., the length of the lever being 20 inches, and the screw $\frac{3}{4}$ pitch?

$20 \times 2 = 40 \times 3.1416 = 125.6$ inches; then,
As $125.6 : .75 :: 6000 : 35.8$ lbs., power required.

N.B.—There are few machines but what, on account of the friction of the parts against one another, will require a third part more power to work them, when loaded, than is requisite to constitute a balance between power and weight.

The following Table shows the estimated power of man or horse as applied to machinery.

Application of the power.	Lbs. Avr. at the rate of 220 feet ℔ minute.		Lbs. Avr. at the rate of one foot ℔ minute.
A man is supposed to be capable of lifting or carrying	27.273	or	6000
A man is supposed to be capable of turning the winch of a crane with a force equal to	28.637	or	6300
When the united efforts of two men are applied to the winch of a crane, the handles being at right angles, each man exerts a force equal to..............	33.499	or	7350
A man is supposed to exert a power in pumping equal to	17.335	or	3814
In ringing, a man exerts a force equal to........	38.955	or	8570
And in rowing	40.955	or	9010
The power of a horse equal to.........	150	or	33000

OF FALLING BODIES.

In bodies falling freely by their own weight, their velocities are as the times, and the spaces as the square of the times; therefore, if the times be as the

numbers	1,	2,	3,	4,	&c.
The velocities will be also	1,	2,	3,	4,	&c.
The spaces passed through	1,	4,	9,	16,	&c.
And the spaces for each time, as the odd numbers	1,	3,	5,	7,	&c.

It has been ascertained by experiment that a body falling freely from rest will descend through $16\frac{1}{12}$ feet in the first second of time, and will then have acquired a velocity which, being continued uniformly, will carry it through $32\frac{2}{12}$ feet in the next second, consequently, if the first series of numbers be expressed in

seconds,	1″	2″	3″	
Velocities in feet will be	$32\frac{2}{12}$	$64\frac{4}{12}$	$96\frac{1}{2}$,	&c.
Spaces in the whole times......	$16\frac{1}{12}$	$64\frac{4}{12}$	$144\frac{3}{4}$,	&c.
And the spaces for each second..	$16\frac{1}{12}$	$48\frac{1}{4}$	$80\frac{5}{12}$,	&c.

To find the velocity a falling body will acquire in any given time.

Rule.—Multiply the time in seconds by 32.166, and the product will be the velocity acquired in feet per second.

Example.—Required the velocity in 7 seconds.

$32.166 \times 7 = 225.162$ feet, velocity acquired.

To find the velocity a body will acquire by falling from any given height.

Rule.—Multiply the space in feet by 64.33, and the square root of the product will be the velocity acquired in feet per second.

EXAMPLE.—Required the velocity a ball will acquire in descending through 201 feet.

$$\sqrt{64.33 \times 201} = 113.7 \text{ feet.}$$

To find the space through which a body will fall in any given time.

RULE.—Multiply the square of the time in seconds by 16.083, and the product will be the space in feet.

EXAMPLE.—Required the space fallen through in 7 seconds.

$$16.083 \times 49 = 788.067 \text{ feet.}$$

NOTE.—The velocity acquired by a body in falling from rest, through a given height, is the same whether it fall freely or descend through a plane any way inclined.

The diameter of a circle perpendicular to the horizon, and any chord terminating at either extremity of that diameter, are fallen through in the same time.

And the velocities which bodies acquire by descending along chords of the same circle are as the lengths of those chords.

TABLE

Of accelerated motion of falling bodies.

Time in seconds of the body's fall.	Space fallen through during each second in feet.	Whole space fallen through in feet.	Velocity acquired at the end of the time.
1	16.095	16.095	32.19
2	48.285	64.380	64.38
3	80.475	144.855	96.57
4	112.665	257.520	128.76
5	144.855	402.375	160.95
6	177.045	579.420	193.14
7	209.235	788.655	225.33
8	241.425	1030.080	257.52
9	273.615	1303.695	289.71
10	305.805	1609.495	321.90

ON PENDULUMS.

A pendulum that vibrates seconds, or 60 in the latitude of London, is 39.1393 inches long; and $\sqrt{39.1393} \times 60 = 375.36$, which serves as a constant number for other pendulums; thus, 375.36, divided by the square root of the pendulum's length, gives the number of vibrations per minute; and divided by the vibrations per minute, gives the square root of the length of pendulums.

EXAMPLE 1.—Required the number of vibrations a pendulum of 25 inches long will make per minute.

$$\frac{375.36}{\sqrt{25}} = 75.072 \text{ vibrations per minute.}$$

EXAMPLE 2.—Required the length of a pendulum to make 80 vibrations per minute.

$$\frac{375.36}{80} = 4.692^2 = 22.014864 \text{ inches long.}$$

Table containing the length of pendulums to vibrate seconds in various parts of the world.

At Sierra Leone	39 01954 in.	At New York	39.10153 in.
" Trinidad	39.01879 "	" Bordeaux	39.11282 "
" Madras	39.02630 "	" Paris	39.12843 "
" Jamaica	39.03508 "	" Edinburgh	39.15540 "
" Rio Janeiro	39.01206 "	" Greenland	39.20328 "

A pendulum vibrating half seconds in the latitude of London is 9.8 inches in length; and for quarter seconds ches.

ON THE VELOCITY OF WHEELS, DRUMS, PULLEYS, &c.

When wheels are applied to communicate motion from one part of a machine to another, their teeth act alternately on each other; consequently, if one wheel contains 60 teeth and another 20, the one containing 20 teeth will make three revolutions, while the other makes but one; and if drums or pulleys are taken in place of wheels, the result will be the same; because their circumferences, describing equal spaces, render their revolutions unequal: from this the rule is derived, namely,

Multiply the velocity of the driver by the number of teeth it contains, and divide by the velocity of the driven; the quotient will be the number of teeth it ought to contain. Or, Multiply the velocity of the driver by its diameter, and divide by the velocity of the driven; the quotient will be the diameter of the driven.

Example 1.—If a wheel that contains 75 teeth makes 16 revolutions per minute, required the number of teeth in another to work in it, and make 24 revolutions in the same time

$$\frac{75 \times 16}{24} = 50 \text{ teeth.}$$

Example 2.—A wheel, 64 inches diameter, and making 42 revolutions per minute, is to give motion to a shaft at the rate of 77 revolutions in the same time: required the diameter of a wheel suitable for that purpose.

$$\frac{64 \times 42}{77} = 34.9 \text{ inches.}$$

EXAMPLE 3.—Required the number of revolutions per minute made by a wheel or pulley 20 inches diameter, when driven by another of 4 feet diameter, and making 46 revolutions per minute.

$$\frac{48 \times 46}{20} = 110.4 \text{ revolutions.}$$

EXAMPLE 4.—A shaft, at the rate of 22 revolutions per minute, is to give motion, by a pair of wheels, to another shaft at the rate of $15\frac{1}{2}$; the distance of the shafts from centre to centre is $45\frac{1}{2}$ inches; the diameters of the wheels at the pitch lines are required.

$$\frac{45.5 \times 15.5}{22 + 15.5} = 18.81 \text{ radius of the driving wheel.}$$

And $\dfrac{45.5 \times 22}{22 + 15.5} = 26.69$ radius of the driven wheel.

EXAMPLE 5.—Suppose a drum to make 20 revolutions per minute, required the diameter of another to make 58 revolutions in the same time.

$58 \div 20 = 2.9$, that is, their diameters must be as 2.9 to 1; thus, if the one making 20 revolutions be called 30 inches, the other will be $30 \div 2.9 = 10.345$ inches diameter.

EXAMPLE 6.—Required the diameter of a pulley, to make $12\frac{1}{2}$ revolutions in the same time as one of 32 inches making 26.

$$\frac{32 \times 26}{12.5} = 66.56 \text{ inches diameter.}$$

EXAMPLE 7.—A shaft, at the rate of 16 revolutions per minute, is to give motion to a piece of machinery at the rate of 81 revolutions in the same time; the motion is to be communicated by means of two wheels and two

pulleys with an intermediate shaft; the driving wheel contains 54 feet, and the driving pulley is 25 inches diameter; required the number of teeth in the other wheel, and the diameter of the other pulley.

$\sqrt{81 \times 16}=36$, the mean velocity between 16 and 81; then, $\frac{16 \times 54}{36} = 24$ teeth; and $\frac{36 \times 25}{81} =$ 11.11 inches, diameter of pulley.

Example 8.—Suppose in the last example the revolutions of one of the wheels to be given, the number of teeth in both, and likewise the diameter of each pulley, to find the revolutions of the last pulley.

$\frac{16 \times 54}{24} = 36$, velocity of the intermediate shaft;

and $\frac{36 \times 25}{11.11} = 81$, the velocity of the machine.

TABLE

For finding the radius of a wheel when the pitch is given, or the pitch of a wheel when the radius is given, that shall contain from* 10 *to* 150 *teeth, and any pitch required.

Num. of Teeth.	*Radius.*	*Num. of Teeth.*	*Radius.*	*Num. of Teeth.*	*Radius.*	*Num. of Teeth.*	*Radius.*
10	1.618	46	7.327	81	12.895	116	18.464
11	1.774	47	7.486	82	13.054	117	18.623
12	1.932	48	7.645	83	13.213	118	18.782
13	2.089	49	7.804	84	13.370	119	18.941
14	2.247	50	7.963	85	13.531	120	19.101
15	2.405	51	8.122	86	13.690	121	19.260
16	2.563	52	8.281	87	13.849	122	19.419
17	2.721	53	8.440	88	14.008	123	19.578
18	2.879	54	8.599	89	14.168	124	19.737
19	3.038	55	8.758	90	14.327	125	19.896
20	3.196	56	8.917	91	14.486	126	20.055
21	3.355	57	9.076	92	14.645	127	20.214
22	3.513	58	9.235	93	14.804	128	20.374
23	3.672	59	9.394	94	14.963	129	20.533
24	3.830	60	9.553	95	15.122	130	20.692
25	3.989	61	9.712	96	15.281	131	20.851
26	4.148	62	9.872	97	15.440	132	21.010
27	4.307	63	10.031	98	15.600	133	21.169
28	4.465	64	10.190	99	15.759	134	21.328
29	4.624	65	10.349	100	15.918	135	21.488
30	4.788	66	10.508	101	16.077	136	21.647
31	4.942	67	10.667	102	16.236	137	21.806
32	5.101	68	10.826	103	16.395	138	21.965
33	5.260	69	10.985	104	16.554	139	22.124
34	5.419	70	11.144	105	16.713	140	22.283
35	5.578	71	11.303	106	16.873	141	22.442
36	5.737	72	11.463	107	17.032	142	22.602
37	5.896	73	11.622	108	17.191	143	22.761
38	6.055	74	11.781	109	17.350	144	22.920
39	6.214	75	11.940	110	17.509	145	23.079
40	6.373	76	12.099	111	17.668	146	23.238
41	6.532	77	12.258	112	17.827	147	23.397
42	6.691	78	12.417	113	17.987	148	23.556
43	6.850	79	12.576	114	18.146	149	23.716
44	7.009	80	12.735	115	18.305	150	23.875
45	7.168						

RULE.—Multiply the radius in the table by the pitch given, and the product will be the radius of the wheel required.

Or, Divide the radius of the wheel by the radius in the table, and the quotient will be the pitch of the wheel required.

EXAMPLE 1.—Required the radius of a wheel to contain 64 teeth, of 3 inch pitch.

$$10.19 \times 3 = 30.57 \text{ inches.}$$

EXAMPLE 2.—What is the pitch of a wheel to contain 80 teeth, when the radius is 25.47 inches?

$$25.47 \div 12.735 = 2 \text{ inch pitch.}$$

Or, set off upon a straight line seven times the pitch given, divide that, or another exactly the same length, into eleven equal parts; call each of those divisions four, or each of those divisions will be equal to four teeth upon the radius.

EXAMPLE.—Were it required to find the diameter of a wheel to contain 21 teeth, the construction would be as follows:—

1	2	3	4	5	6	7				
1	2	3	4	5	6	7	8	9	10	11

<...4......8....12......16...20>

Thus, 5 divisions and $\frac{1}{4}$ of another equal the radius of the wheel.

Regular approved proportions for wheels with flat arms in the middle of the ring, and ribs, or feathers, on each side.

The length of the teeth = $\frac{5}{9}$ the pitch, besides clearance, or $\frac{6}{9}$ the pitch, clearance included.

Thickness of the teeth .... $\frac{4}{9}$ the pitch.
Breadth on the face ....$2\frac{1}{2}$ "
Edge of the rim.................. $\frac{4}{9}$ "
Rib projecting inside the rim ...... $\frac{4}{9}$ "
Thickness of the flat arms.......... $\frac{4}{9}$ "

Breadth of the arms at the points = 2 teeth and $\frac{1}{4}$ the pitch, getting broader towards the centre of the wheel in the proportion of $\frac{1}{2}$ inch to every foot in length.

Thickness of the ribs, or feathers, $\frac{1}{4}$ the pitch.

Thickness of metal round the eye, or centre, $\frac{7}{9}$ the pitch.

Wheels made with plain arms, the teeth are in the same proportion as above; the ring and the arms are each equal to one cog or tooth in thickness, and the metal round the eye same as above, in feathered wheels.

To find the power that a cast iron wheel is capable of transmitting at any given velocity.

RULE.—Multiply the breadth of the teeth, or face of the wheel in inches, by the square of the thickness of one tooth, and divide the product by the length of the teeth, the quotient is the strength in horses' power at a velocity of 136 feet per minute.

EXAMPLE.—Required the power that a wheel of the following dimensions ought to transmit with safety, namely,

Breadth of teeth........$7\frac{1}{2}$ inches,
Thickness..............1.4
And length.................2

$1.4^2 = 1.96$, and $\frac{7.5. \times 1.96}{2} = 7.35$ horses' power.

The strength at any other velocity is found by multiplying the power so obtained by any other required velocity, and by .0044, the quotient is the power at that velocity.

Suppose the wheel as above, at a velocity of 320 feet per minute.

$7.35 \times 320 \times .0044 = 10.3488$ horses' power.

ON THE MAXIMUM VELOCITY AND POWER OF WATER WHEELS.

Since publishing the first edition of this work, I have endeavoured, as far as possible, to acquire the most improved practical principles of water wheels as a moving power; and

1.—*Of undershot wheels.*

The term undershot is applied to a wheel when the water strikes at, or below, the centre. And the greatest effect is produced when the periphery of the wheels moves with a velocity of .57 that of the water; —hence, to find the velocity of the water, multiply the square root of the perpendicular height of the fall in feet by 8, and the product is the velocity in feet per second.

EXAMPLE.—Required the maximum velocity of an undershot wheel, when propelled by a fall of water 6 feet in height.

$\sqrt{6} = 2.45 \times 8 = 19.6$ feet velocity of water.

And $19.6 \times .57 = 11.17$ feet per second for the wheel.

2.—*Of breast and overshot wheels.*

Wheels that have the water applied between the centre and the vertex are styled breast wheels, and overshot when the water is brought over the wheel and laid on the opposite side; however, in either case the maximum velocity is $\frac{2}{3}$ that of the water; hence, to find the head of water proper for a wheel at any velocity, say,

As the square of 16.083, or 258.67, is to 4, so is the

square of the velocity of the wheel in feet per second to the head* of water required.

EXAMPLE.—Required the head of water necessary for a wheel of 24 feet diameter, moving with a velocity of 5 feet per second.

$$\frac{5 \times 3}{2} = 7.5 \text{ feet velocity of the water.}$$

And 258.67 : 4 :: 7.5^2 : .87 feet, head of water required.

But one-tenth of a foot of head must be added for every foot of increase in the diameter of the wheel, from 15 to 20 feet, and .05 more for every foot of increase from 20 to 30 feet, commencing with five-tenths for a 15 feet wheel.

This additional head is intended to compensate for the friction of water in the aperture of the sluice to keep the velocity as 3 to 2 of the wheel; thus, in place of .87 feet head for a 24 feet wheel, it will be .87 + 1.2 = 2.07 feet head of water.

If the water flow from under the sluice, multiply the square root of the depth in feet by 5.4, and by the area of the orifice also in feet, and the product is the quantity discharged in cubic feet per second.

Again, if the water flow over the sluice, multiply the square root of the depth in feet by 5.4; and $\frac{2}{3}$ of the product multiplied by the length and depth, also in feet, gives the number of cubic feet discharged per second nearly.

EXAMPLE 1.—Required the number of cubic feet per second that will issue from the orifice of a sluice 5 feet long, 9 inches wide, and 4 feet from the surface of the water.

$$\sqrt{4} = 2 \times 5.4 = 10.8 \text{ feet velocity,}$$

And $5 \times .75 \times 10.8 = 40.5$ cubic feet per second.

* By *head* is understood the distance between the aperture of the sluice and where the water strikes upon the wheel.

EXAMPLE 2.—What quantity of water per second will be expended over a wear, dam, or sluice, whose lengths is 10 feet, and depth 6 inches?

$$\sqrt{.5} = .2236 \times 5.4 = \frac{1.20744 \times 2}{3} = .80496$$

feet velocity; then, $10 \times .5 = 5$ feet, and $.80496 \times 5 = 4.0248$ cubic feet per second nearly.

In estimating the power of water wheels, half the head must be added to the whole fall, because 1 foot of fall is equal to 2 feet of head; call this the effective perpendicular descent; multiply the weight of the water per second by the effective perpendicular descent and by 60; divide the product by 33,000, and the quotient is the effect expressed in horses' power.

EXAMPLE 1.—Given 16 cubic feet of water per second, to be applied to an undershot wheel, the head being 12 feet, required the power produced.

$$12 \div 2 = 6 \text{ and } \frac{6 \times 16 \times 62.5 \times 60}{33000} = 10.9$$

horses' power nearly.

EXAMPLE 2.—Given 16 cubic feet of water per second, to be applied to a high breast or an overshot wheel, with 2 feet head and 10 feet fall; required the power.

$$2 \div 2 = 1 \text{ and } \frac{\overline{1 + 10} \times 16 \times 62.5 \times 60}{33000} = 20$$

horses' power.

N.B.—Only about two-thirds of the above results can be taken as real communicative power to machinery.

OF THE CIRCLE OF GYRATION IN WATER WHEELS.

The centre or circle of gyration is that point in a revolving body into which, if the whole quantity of matter were collected, the same moving force would generate the same angular velocity, which renders it of the utmost importance in the erection of water wheels, and the motion ought always to be communicated from that point when it is possible.

To find the circle of gyration.

Rule.—Add into one sum twice the weight of the shrouding, buckets, &c., multiplied by the square of the radius, $\frac{2}{3}$ of the weight of the arms, multiplied by the square of the radius, and the weight of the water multiplied by the square of the radius also; divide the sum by twice the weight of the shrouding, arms, &c., added to the weight of the water, and the square root of the quotient is the distance of the circle of gyration from the centre of suspension nearly.

Example.—Required the distance of the centre of gyration from the centre of suspension in a water wheel 22 feet diameter, shrouding, buckets, &c., $=$ 18 tons, arms $=$ 12 tons, and water $=$ 10 tons.

$$\begin{array}{rrrrr} & 22 \div 2 = & 11 \text{ and } 11^2 = & & 121 \\ \text{Then,} & 18 \times 2 = & 36 & \times\, 121 = & 4356 \\ & \frac{2}{3} \text{ of } 12 = & 8 & \times\, 121 = & 968 \\ & \text{water} = & 10 & \times\, 121 = & \underline{1210} \\ & & & & 6534 \end{array}$$

And $\overline{18 + 12} \times 2 = 60 + 10 = 70$; hence,

$\sqrt{\frac{6534}{70}} = 9.6$ feet from the centre of suspension nearly.

Table of angles for windmill sails.

The radius is supposed to be divided into six equal parts, and $\frac{1}{6}$ from the centre is called 1, the extremity being denoted by 6.

No.	Angle with the Plane of Motion.	
1	18°	24°
2	19	21
3	18	18
4	16	14
5	12½	9
6	7	3 *extremity.*

The first column contains the angles according to Smeaton; but experience has taught us that the angles in the second column are preferable.

THE VELOCITY OF THRASHING MACHINES, MILLSTONES, BORING IRON, &c.

The drum or beaters of a thrashing machine ought to move with a velocity of about 3000 feet per minute; hence, divide 11460 by the diameter of the drum in inches; or 955 by the diameter of the drum in feet; and the quotient is the number of revolutions required per minute, And

The feeding rollers must make half the revolutions of the drum, when their diameters are about 3½ inches.

If the machine is driven by horses, their velocity ought to be from 2½ to 3 times round a 24 feet ring per minute.

Divide 500 by the diameter of a millstone, in feet, or 6000 by the diameter in inches, and the quotient is the number of revolutions required per minute.

In boring cast iron the cutters ought to have a velocity of about 108 inches per minute, or divide 36 by the diameter in inches, the quotient is the number of revolutions of the boring head per minute.

And divide 100 by the diam. in inches, the quotient is the number of revolutions per minute, for turning wrought iron in general, and about half that velocity for cast iron.

OF PUMPS AND PUMPING ENGINES.

Pumps are chiefly designated by the names of lifting and force pumps: lifting pumps are applied to wells, &c., where the height of the bucket, from the surface of the water, must not exceed 33 feet; this being nearly equal to the pressure of the atmosphere, or the height to which water would be forced up into a vacuum by the pressure of the atmosphere. Force pumps are applicable on all other occasions, as raising water to any required height, supplying boilers against the force of the steam, hydrostatic presses, &c.

The power required to raise water to any height is as the weight and velocity of the water with an addition of about $\frac{1}{5}$ of the whole power for friction; hence the rule,—Multiply the perpendicular height of the water, in feet, by the velocity, also in feet, and by the square of the pump's diameter in inches, and again by .341; (this being the weight of a column of water 1 inch diameter, and 12 inches high, in lbs. avoirdupois;) divide the product by 33,000, and $\frac{1}{5}$ of the quotient added to the whole quotient, will be the number of horses' power required.

Example.—Required the power necessary to overcome the resistance and friction of a column of water 4 inches diameter, 60 feet high, and flowing with a velocity of 130 feet per minute.

$$\frac{60 \times 130 \times 4^2 + .341}{33000} = \frac{1.3}{5} = .26 + 1.3 = 156$$

horses' power nearly.

Note.—Hot liquor pumps, or pumps to be employed in raising any fluid where steam is generated, require to be placed in the fluid, or as low as the bottom of it, on account of the steam filling the pipes, and acting as a counterpoise to the atmosphere; and the diameter of the pipes to and from a pump ought not to be less than $\frac{2}{3}$ of the pump's diameter.

The diameter of a pump and velocity of the water given, to find the quantity discharged in gallons, or cubic feet, in any given time.

RULE.—Multiply the velocity of the water, in feet per minute, by the square of the pump's diameter in inches, and by .034 for imperial gallons; or, .0005454 for cubic feet, and the product will be the number of gallons, or cubic feet, discharged in the given time, nearly.

EXAMPLE.—What is the number of imperial gallons of water discharged per hour by a pump 4 inches diameter, the water flowing at the rate of 130 feet per minute?

$$130 \times 60 = 7800 \text{ feet per hour.}$$
$$\text{And, } 7800 \times 4^2 \times .034 = 4243.2 \text{ gallons.}$$

The length of stroke and number of strokes given, to find the diameter of a pump, and number of horses' power that will discharge a given quantity of water in a given time.

RULE 1.—Multiply the number of imperial gallons required, in the given time, by 353, or the number of cubic feet by 2201, and divide the product by the velocity of the water, in inches, and the square root of the quotient will be the pump's diameter, in inches.

2.—Multiply the number of gallons per minute by 10, or the number of cubic feet by 62.5, and by the perpendicular height of the water in feet, divide the product by 33,000, then will $\frac{1}{5}$ of the quotient, added to the whole quotient, be the number of horses' power required.

EXAMPLE.—Required the diameter of a pump, and number of horses' power, capable of filling a cistern 20 feet long, 12 feet wide, and $6\frac{1}{2}$ feet deep, in 45 minutes,

whose perpendicular height is 53 feet; the pump to have an effective stroke of 26 inches, and make 30 strokes per minute.

$$20 \times 12 \times 6.5 = 1560 \text{ cubic feet, and}$$

$$\frac{1560}{45} = 34.66 \text{ cubic feet per minute.}$$

Then, $\sqrt{\dfrac{34.66 \times 2201}{26 \times 30}} = 9.89$ inches diameter of pump.

And $\dfrac{34.66 \times 62.5 \times 53}{33000} = \dfrac{3.48}{5} = .69 + 3.48 = 4.17$ horses' power.

To find the time a cistern will take in filling, when a known quantity of water is going in, and a known portion of that water is going out, in a given time.

RULE.—Divide the content of the cistern, in gallons, by the difference of the quantity going in, and the quantity going out, and the quotient is the time in hours and parts that the cistern will take in filling.

EXAMPLE.—If 30 gallons per hour run in and $22\frac{1}{2}$ gallons per hour run out of a cistern capable of containing 200 gallons, in what time will the cistern be filled?

$30 - 22.5 = 7.5$, and $200 \div 7.5 = 26.666$, or 26 hours and 40 minutes.

To find the time a vessel will take in emptying itself of water.

Mr. Banks ascertained, from very accurate experiments, that a vessel, 3.166 feet long and 2.705 inches diameter, would empty itself in 3 minutes and 16 seconds, through an orifice in the bottom, whose area

is .0141 inches; and another 6.458 feet long, the diameter and orifice, as before, would do the same in 4 minutes and 40 seconds; hence, from these experiments, a rule is obtained, namely,

Multiply the square root of the depth in feet by the area of the falling surface in inches, divide the product by the area of the orifice, multiplied by 3.7, and the quotient is the time required in seconds, nearly.

Example.—How long will it require to empty a vessel of water, 9 feet high, and 20 inches diameter, through a hole $\frac{3}{4}$ inch in diameter?

$\sqrt{9} = 3$, the square root of the depth,
314.16 inches, area of the falling surface,
.4417 inches, area of the orifice;

Then, $\dfrac{314.16 \times 3}{.4417 \times 3.7} = 576.7$ seconds, or
9 minutes and 36 seconds.

On the pressure of fluids.

The side of any vessel containing a fluid sustains a pressure equal to the area of the side, multiplied by half the depth; thus,

Suppose each side of a vessel to be 12 feet long and 5 feet deep, when filled with water, what pressure is upon each side?

$12 \times 5 = 60$ feet, the area of the side,
2.5 feet = half the depth, and
62.5 lbs. = the weight of a cubic foot of water.

Then, $60 \times 2.5 \times 62.5 = 9375$ lbs.

To find the number of imperial gallons contained in a yard of pipe of any given diameter.

Rule.—Square the diameter of the pipe in inches, cut off one integer for a decimal; again, multiply the square by 2, the product is hundredths, &c., of a

gallon, which add to the former product, and the sum will be the content of the pipe in imperial gallons nearly,

EXAMPLE 1.—Required the number of imperial gallons contained in each yard of a $6\frac{1}{4}$ inch pipe.

$$6.25^2 = 39.0625 \text{ and } 3.90625 \times 2 = 78125.$$

Then, 3.90625
$+ \quad 78125$
$= 3.984375$ gallons.

EXAMPLE 2.—Required the content of a yard of 4 inch pipe in imperial gallons.

$4^2 = 16$, and $16 \times 2 = 32$, then 1.6
$+ \quad 32$
$= 1.632$ gallons.

To find the weight that a given power can raise by one of Bramah's pumps, or hydrostatic presses.

RULE.—Multiply the square of the diameter of the ram in inches by the power applied in lbs., and by the effective leverage of the pump handle; divide the product by the square of the pump's diameter, also in inches, and the quotient is the weight that the power is equal to.

EXAMPLE.—What weight will a power of 50 lbs. raise by means of an hydrostatic press, whose ram is 7 inches diameter, pump $\frac{7}{8}$, and the effective leverage of the pump handle being as 6 to 1 ?

$$\frac{7^2 \times 50 \times 6}{.875^2} = 19200 \text{ lbs., or 8 tons 11 cwt.}$$

In the following rules for pumping engines the boiler is supposed to be loaded with about $2\frac{1}{2}$ lbs. per square inch, and the barometer attached to the condenser indicating 26 inches on an average, or 13 lbs. $= 15\frac{1}{2}$ lbs., from which deduct $\frac{1}{3}$ for friction, leaves a pressure of 10 lbs. nearly upon each square inch of the piston.

To find the diameter of a cylinder to work a pump of a given diameter for a given depth.

RULE.—Multiply the square of the pump's diameter in inches by $\frac{1}{3}$ of the depth of the pit in fathoms, and the square root of the product will be the cylinder's diameter in inches.

EXAMPLE.—Required the diameter of a cylinder to work a pump 12 inches diameter and 27 fathoms deep.

$$\sqrt{12^2 \times 9} = 36 \text{ inches diameter.}$$

To find the diameter of a pump that a cylinder of a given diameter can work at a given depth.

RULE.—Divide three times the square of the cylinder's diameter in inches by the depth of the pit in fathoms, and the square root of the quotient will be the pump's diameter in inches.

EXAMPLE.—What diameter of a pump will a 36 inch cylinder be capable of working 27 fathoms deep?

$$\sqrt{\frac{36^2 \times 3}{27}} = 12 \text{ inches diameter.}$$

To find the depth from which a pump of a given diameter will work by means of a cylinder of a given diameter.

RULE.—Divide three times the square of the cylinder's diameter in inches by the square of the pump's diameter also in inches, and the quotient will be the depth of the pit in fathoms.

EXAMPLE.—Required the depth that a cylinder of 36 inches diameter will work a pump of 12 inches diameter.

$$\sqrt{\frac{36^2 \times 3}{144}} = 27 \text{ fathoms.}$$

APPROXIMATE RULES FOR CALCULATING LIQUIDS.

To find the number of imperial gallons contained in any square or rectangular cistern.

Rule.—Multiply the content of the cistern in cubic feet by 6.232, or the content in cubic inches by .003607, and the product is the number of gallons nearly.

Example 1.—A cistern that is 8 feet long, $4\frac{1}{2}$ feet wide, and 3 feet deep, required its contents in imperial gallons.

$8 \times 4.5 \times 3 = 108$ cubic feet.

And $108 \times 6.232 = 673.056$ gallons.

Or, 8 feet = 96 inches; $4\frac{1}{2}$ feet = 54 inches, and 3 feet = 36 inches; then,

$96 \times 54 \times 36 = 186624$ cubic inches,

And $186624 \times .003607 = 673.152$ gallons.

Any two dimensions of a square or rectangular cistern being given, to find the third, that shall contain any number of imperial gallons required.

Rule.—Divide the number of gallons that the cistern is required to contain by the product of the two dimensions multiplied by either of the multipliers as above, according as the dimensions are given in feet or inches, and the quotient will be the third dimensions of the cistern nearly.

Example.—Required the depth of a cistern to contain 800 imperial gallons, the length being $6\frac{1}{2}$ feet, and width $4\frac{3}{4}$ feet.

$6.5 \times 4.75 \times 6.232 = 192.413$; and

$800 \div 192.413 = 4.16$ feet deep.

To find the content of a cylinder in imperial gallons.

RULE.—Multiply the square of the diameter in feet by the length of the cylinder, also in feet, and by 4.895;

Or, the square of the diameter in inches by the length in feet and by 0.34;

Or, the square of the diameter in inches by the length also in inches, and by .002832, and the product will be the content in gallons nearly.

EXAMPLE.—How many imperial gallons are contained in a well 22½ feet deep, and 3½ feet diameter?

$3.5^2 \times 22.5 \times 4.895 = 1349.18$ gallons.

Or, 3½ feet = 42 inches,

And, $42^2 \times 22.5 \times .034 = 1349.46$ gallons.

Also, 22½ feet = 270 inches,

And, $42^2 \times 270 \times .002832 = 1349.3$ gallons.

The length of a cylinder given, to find the diameter, or the diameter given, to find the length that shall contain any number of imperial gallons required.

RULE.—Divide the number of gallons that the cylinder is required to contain, by the length in feet multiplied by 4.895, and the square root of the quotient is the diameter in feet, and parts of a foot;

Or, divide the number of gallons by the square of the diameter in feet multiplied by 4.895, and the quotient is the length in feet and parts of a foot,—and

If the dimensions are in inches in place of feet, use 354 in place of 4.895.

EXAMPLE.—What must be the diameter of a cylinder to contain 5 imperial gallons, when the length is 20 inches?

$$\sqrt{\frac{354 \times 5}{20}} = 9.4 \text{ inches diameter.}$$

The cube of the diameter of a sphere in feet, multiplied by 3.263 = imperial gallons;

Or, the cube of the diameter of a sphere in inches, multiplied by .001888 = imperial gallons.

NOTE.—The weight of a cubic foot of water = 62.5 lbs. avoirdupois.

Weight of a cubic inch = .03617 lbs. avoirdupois.

Weight of a column of water 12 inches high and 1 inch square = .434 lbs. avoirdupois.

Weight of a cylindrical foot of water = 49.1 lbs. avoirdupois.

Weight of a cylindrical inch = .02842 lbs. avoirdupois.

Weight of a column of water 12 inches high and 1 inch diameter = .341 lbs. avoirdupois.

Take for example a column of water 11 inches diameter and 15 feet high, required its weight.

$11^2 \times 15 \times .341 = 618.915$ lbs. avoirdupois.

11.2 imperial gallons of water = 1 cwt.

224 imperial gallons of water = 1 ton.

1.8 cubic feet of water .... = 1 cwt.

35.84 .... = 1 ton.

1 .... = $6\frac{1}{4}$ imperial gallons.

1 cylindrical foot................. = 5 imperial gallons.

OF STEAM AND THE STEAM ENGINE.

Steam is the visible moist vapour which arises from all bodies that contain juices easily expelled from them by heats not sufficient for their combustion.

But steam, as applicable at present to the steam-engine, is highly rarified water, the particles of which are expanded by the absorption of caloric, or the matter of heat.

Water rises in vapour at all temperatures, but is confined to the surface of the fluid acted upon until it has attained 212° Fahrenheit, called the boiling point; at that heat steam ascends through it, preventing its elevation to a higher temperature by carrying the heat off in a latent form.

The latent heat of steam at the common pressure of the atmosphere, according to very accurate experiments, is found to be 1000°; and we know that the sensible, or thermometric heat $= 212°$.—Now $212° - 32° = 180°$, and $1000 + 180 = 1180°$; therefore, steam at 212° is highly rarified water, containing 1180° of heat; hence, to find the latent heat of steam at any other temperature, subtract the sensible heat from 1180°, and the difference $+ 32° =$ the latent heat.

Example.—Required the latent heat of steam whose sensible heat is 224°.

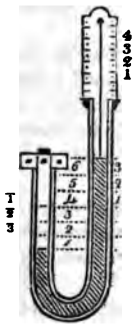
$$1180 - 224 = 956,$$

$$\text{And } 956 + 32 = 988° \text{ latent heat.}$$

One cubic inch of water produces about 1700 cubic inches of steam at 212°, or the common pressure of the atmosphere; but the boiling point varies considerably, according to the pressure on the surface of the fluid, and, of course, materially affects the density of the vapour produced; thus, in a vacuum, water boils at about 90°; under common pressure, at 212°; and when pressed with a column of mercury 5 inches in height, will not boil

until heated to 217°; each inch of mercury producing by its pressure a rise of about 1° in the thermometer.

The pressure or force of steam in the boiler (less than the weight upon the safety valve) is generally indicated by a column of mercury in a bent iron tube, which causes the range of the float to be only half the range of the mercury, 2 inches of mercury being nearly equal to 1 lb. pressure of steam in the boiler, thus:—

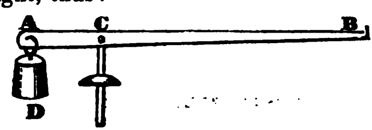


Each inch of the float indicates a pressure of 1lb. nearly.

—Level of the mercury when there is no pressure of steam.

To calculate the effect of a lever and weight upon the safety valve of a steam boiler, &c.

The lever, in all cases, is supposed to be made finished, and balanced, by a known weight or weights, on the short end, making that point where it rests, or is attached to the valve, the centre of motion; then that weight, added to the weight of the lever, is the effective weight upon the valve, independent of any other additional weight, thus:



Then there are three different ways that it may be required to calculate the lever.

1.—*When a certain pressure may be required upon the valve, the distance of the weight upon the lever, and distance of the valve from the centre of motion given, to find what weight will be required upon the lever at that distance.*

Rule.—From the required pressure on the valve in lbs. subtract the weight of the valve, plus the effective weight of the lever, multiply the remainder by the distance between the fulcrum and the valve, divide the product by the distance between the fulcrum and the weight, and the quotient is the weight in lbs. required to be placed upon the lever at that distance.

2.—*When a certain pressure upon the valve is required, the weight upon the lever and distance of valve from the centre of motion given, to find where that weight must be placed.*

Rule.—From the required weight upon the valve in lbs. subtract the weight of the valve, plus the effective weight of the lever, multiply the remainder by the distance between the fulcrum and the valve, divide the product by the weight in lbs. upon the lever, and the quotient is the distance in inches from the fulcrum that the weight must be placed.

3.—*When the distance of weight, distance of valve from the centre of motion, and weight upon the lever given, to find what pressure is upon that valve.*

Rule.—Multiply the weight in lbs. upon the lever by the distance in inches to the fulcrum, divide the product by the distance between the fulcrum and the valve, and the quotient, plus the weight of the valve and effective weight of the lever, equal the weight upon the valve in lbs.

Example 1.—Suppose the lever A B (as above) to be 24 inches in length, and the valve C placed 5

inches from the centre of motion A, what weight must be placed upon the lever 20 inches from A, to equal 80 lbs. on the valve C, the weight of the lever being 2 lbs., the weight D, which balances the lever, $4\frac{1}{2}$ lbs., and the weight of the valve 3 lbs.

2 lbs, weight of the lever.
4.5 to balance ditto.
3 weight of the valve.

$$9.5 \text{ lbs. then } \frac{\overline{80 - 9.5} \times 5}{20} = 17.625 \text{ lbs.}$$

Example 2.—Suppose, as in the last example, the weight upon the lever equal 17.625 lbs., it is required at what distance from A the weight must be placed to equal 80 lbs. at C.

$$\frac{\overline{80 - 9.5} \times 5}{17.625} = 20 \text{ inches.}$$

Example 3.—Suppose, as before, that a weight of 17.625 lbs. is placed upon the lever 20 inches from A, required the pressure at C, the distance from the centre of motion being 5 inches, and the effective weight of the lever at that point equal $6\frac{1}{2}$ lbs., also the weight of the valve 3 lbs.

$$\frac{17.625 \times 20}{5} = 70.5$$
$$+ \quad 6.5$$
$$+ \quad 3$$
$$= 80 \text{ lbs.}$$

To find the proper diameter for a safety valve.

Rule.—Multiply the bottom surface of the boiler, or surface immediately exposed to the action of the fire, in feet, by the multiplier opposite to the pressure in lbs. on each square inch of the safety valve, and the square root of the product is the valve's diameter in inches at the narrowest part. If the boiler is to have two safety

valves, then the square root of half the product equal the diameter of each.

Pressure in lbs. per square inch.	Multipliers.
3	.356
4	.353
5	.348
6	.344
7	.339
8	.336
10	.329
12	.321
15	.315
20	.305
25	.293
30	.289
35	.282
40	.275
45	.270
50	.264

Table of the elastic force of steam on a square inch.

Steam with a pressure of	lbs. on a square inch, equal	lbs. on a circular inch; and to maintain that pressure requires to be kept at a uniform temperature of °F	and will support a column of mercury	inches in height.
2½	1.963	220	5.15	
3	2.356	222	6.18	
3½	2.749	223½	7.21	
4	3.141	225½	8.24	
4½	3 534	227	9.27	
5	3.927	228½	10.3	
5½	4.320	230	11.3	
6	4.712	231½	12.3	
6½	5.105	233	13.4	
7	5.498	234	14.4	
7½	5.890	235	15.4	
8	6 283	236	16.5	
8½	6.676	237½	17.5	
9	7.068	239	18.5	
9½	7.461	240	19.6	
10	7.854	241	20.6	
10½	8.247	242	21.6	
11	8.639	243	22.6	
11½	9.032	244	23.7	
12	9.424	245½	24.7	
15	11.78	252	30.9	
20	15.71	261	41.2	
25	19.63	269	51.5	
30	23.56	276	61.8	
35	27.49	283	72.1	
40	31.41	289	82.4	
45	35.34	294½	92.7	
50	39.27	300	103	

Multiply the degrees of heat in either this or the following table by .06, and the product will be the

superficial feet of flue plate exposed to the action of the fire for each horse power.

And multiply the degrees of heat by .41, and the product will be the areal inches of furnace bar for each horse power.

Table of the elastic force of steam on a circular inch.

Steam with a pressure of		lbs. on a circular inch, equal		lbs. on a square inch; and to maintain that pressure requires to be kept at a uniform temperature of	°F	and will support a column of mercury		inches in height.
	2½		3.183		222½		6.56	
	3		3.819		224½		7.87	
	3½		4.456		226½		9.18	
	4		5.093		228½		10.5	
	4½		5.729		230½		11.8	
	5		6.366		232		13.1	
	5½		7.002		234		14.4	
	6		7.639		235½		15.7	
	6½		8.276		236½		17.0	
	7		8.912		238½		18.3	
	7½		9.549		239½		19.7	
	8		10.18		241		21.0	
	8½		10.82		242½		22.3	
	9		11.45		244		23.6	
	9½		12.09		245½		24.9	
	10		12.73		247		26.2	
	10½		13.36		248½		27.5	
	11		14.00		250		28.9	
	11½		14.64		251		30.1	
	12		15.27		252½		31.5	
	15		19.09		259		39.3	
	20		25.46		270		52.5	
	25		31.83		278½		65.6	
	30		38.19		287		78.7	
	35		44.56		294		91.8	
	40		50.92		300½		105	
	45		57.20		305		118	
	50		63.66		309		131	

Proportions of fuel.

The proportion that various substances bear to each other in producing heats sufficient to raise equal quan-

tities of water to equal temperatures are nearly as follows:

Coke	0.375	Culm or Slack	1.875
Coal	1.000	Wood	2.875

Hence, multiply the degress of heat in either of the preceding tables by the following numbers opposite the material by which the steam is to be produced, and the product will be the weight in lbs. avoirdupois that is required on an average per hour for each horse power:—

Coke	.024	Slack	.118
Coal	.063	Wood	.18

To find the height of a column of water to supply a steam boiler against any pressure of steam required.

RULE.—Multiply the pressure in pounds (upon a square inch of the boiler) by 2.5, and the product will be the height in feet above the surface of water in the boiler.

EXAMPLE.—Required the length of feed pipe capable of supplying a boiler with water when the pressure of steam is 4 pounds per square inch.

$2.5 \times 4 = 10$ feet above the surface of the water in the boiler.

STEAM ENGINE is the name of a machine which derives its moving powers from the elasticity and condensibility of steam.

Steam, to produce a maximum of useful effect as a moving power, requires to be reduced to a certain determined velocity, and although this maximum velocity has been exhibited to the public by various eminent writers upon the steam engine, still discrepancies exist amongst practical engineers; and no universally acknowledged rules have as yet been established; however, the following tables may be relied upon as exhibiting the results deduced from the most celebrated

rules, and tested by many engines doing the greatest amount of duty, as proved by accurate trials with indicators of the most recent and approved construction.

Length of Stroke in Ft. and In.	Number per Minute.	Velocity in Feet per Minute.	Length of Stroke in Ft. and In.	Number per Minute.	Velocity in Feet per Minute.
2 0	43	172	4 6	24¼	218¼
2 6	38	190	5 0	22	220
3 0	34	204	6 0	19	228
3 6	30	210	7 0	17½	245
4 0	27	216	8 0	16	256

N.B.—These are to be considered as the velocities of land engines, or engines whose connecting rods are not less than three times the length of stroke; but marine engines, being generally confined to connecting rods of not more than 2 or 2½ times the length of stroke, have heir maximum velocities considerably reduced. Hence, the subjoined table will be found pretty correct when the periphery of the wheels moves with a velocity of about 1300 feet per minute, and the floats, or paddle boards, calculated by the following rules, which I have found, in practice, to produce the greatest satisfaction, namely, economizing of fuel, a steady supply of steam, without waste, and the vessel propelled quicker than when the surface of the floats was less, and moving at a greater velocity.

Table of velocities for marine engines.

Length of Stroke in Ft. and In.	Number per Minute.	Velocity in Feet per Minute.	Length of Stroke in Ft. and In.	Number per Minute.	Velocity in Feet per Minute.
2 0	42	168	4 0	24	192
2 3	39½	177¾	4 6	21½	193½
2 6	36	180	5 0	20	200
2 9	33	181	5 6	19	209
3 0	31	186	6 0	18	216
3 6	27	189	7 0	15¾	220½

To find the surface of the floats or paddle boards.

RULE 1.—Multiply the number of horses' power hat the engine is equal to by 3.75, divide the product y the diameter of the wheel in feet, and the quotient s the area of each float, or paddle board.

RULE 2.—Multiply the area of the floats by .54, he product is the length in feet; then divide the area y the length, and the quotient is the breadth.

EXAMPLE.—Required the area, length, and breadth f each paddle board, for a steam vessel with two enines of 80-horse power each, and wheels of 20 feet iameter.

$$\frac{80 \times 3.75}{20} = 15 \text{ feet area.}$$

$15 \times .54 = 8.1$ feet the length of each board.

And $15 \div 8.1 = 1.85$ or 1 foot 10 inches in breadth.

And when there is only one engine in the vessel, of the quotient is the area of each board nearly.

Each wheel, from 12 to 14 feet diameter, ought to ave 12 floats; from 14 to 16 feet diameter, 14 floats; om 16 to 18 feet diameter, 16 floats; and from 18 o 22 feet diameter, 18 floats, &c.

'rinciples upon which the rule is founded for calculating the power of a steam engine.

Hitherto it has been customary, in estimating the ower of condensing engines, to reckon the force of he steam at a constant quantity, namely, 2½ lbs. per ircular inch, totally disregarding any extra pressure in he boiler, or increased weight upon the safety valve.

Hence, in order to form a rule whereby to approxiate more nearly to the real effective power of the enine, it was necessary first to ascertain the effective orce of the steam,—And,

To determine this, I recently made a series of experiments upon engines without any extra lap upon the

valves, whereby to work expansively, when I found that, on account of the nature of the valve's motion, only about three-fourths of the stroke was performed by steam at, or near, the density of the steam in the boiler, the stroke, of course, being terminated expansively; hence, the whole effective force of the steam thus applied can only be taken at about four-fifths of its original pressure.

The benefit arising from the condenser is on an average equal to 26 inches of mercury, or about 13lbs. per square inch, consequently, 13 plus four-fifths of the pressure on each square inch of the safety valve, equal the whole effective force on each square inch of the piston's area.

Then about $8\frac{1}{4}$lbs. is expended in overcoming the resistance and friction of a condensing engine, and may be thus estimated: 13 minus $8\frac{1}{4}$ equal $4\frac{3}{4}$, and $4\frac{3}{4}$ plus $\frac{4}{5}$ths of the weight upon each square inch of the safety valve equal the whole amouut of useful effect in giving motion to machinery.

The process of calculation may be simplified thus: $4\frac{3}{4}$lbs. per square inch = 3.73 lbs. per circular inch, by which means the circle only requires to be squared, and the labour of multiplying by .7854 is dispensed with.

GENERAL RULES.

1.—Multiply the square of the cylinder's diameter in inches by 3.73 plus $\frac{4}{5}$ths the pressure on each circular inch of the safety valve, and by the velocity of the piston in feet per minute; divide the product by 33000, and the quotient is the effect of the engine expressed in horses' power.

Example.—Suppose a cylinder $24\frac{1}{2}$ inches diameter, stroke 4 feet, or 200 feet velocity per minute, and the

weight upon the safety valve 3.5 lbs. per circular inch, required the effective power.

$\frac{4}{5}$ths of 3.5 = 2.8, and 3.73 + 2.8 = 6.53 lbs. effective force.

$$\text{Then } \frac{24.5^2 \times 6.53 \times 200}{33000} = 24 \text{ horses' power.}$$

2.—Multiply 33000 by the number of horses' power required, and divide the product by the velocity of the piston in feet per minute, multiplied by 3.73 plus $\frac{4}{5}$ths the pressure on each circular inch of the safety valve, and the square root of the quotient is the cylinder's diameter in inches.

EXAMPLE.—Required the diameter of a cylinder for an engine of 30 horses' power, with a 6 feet stroke, or 228 feet per minute, and steam at $2\frac{1}{2}$ lbs. per circular inch.

$\frac{4}{5}$ths of 2.5 = 2; and 3.73 + 2 = 5.73 lbs. effective force.

$$\text{Hence, } \frac{33000 \times 30}{228 \times 5.73} = \sqrt{758} = 27\tfrac{1}{2} \text{ inches diameter.}$$

NOTE.—To obtain four-fifths of the pressure of steam, multiply the original pressure by 4 and divide by 5, the quotient is the pressure required.

The above are to be taken as general practical rules for engines not working expansively further than what is compulsory from the nature of the slide valve, but where engines are worked more expansively, and greater accuracy required, recourse must be had to the following rules for obtaining the uniform force of the steam.

RULE 1.—Divide the length of the stroke in inches by the distance (also in inches) that the piston moves before the steam is shut off, and divide the pressure on the boiler in lbs. by the quotient:—

2.—Add 1 to the hyperbolic logarithm of the number of times to which the steam is expanded, and multiply the logarithm by the number of lbs. to which the steam is expanded, and the product is the uniform force of the steam acting throughout the whole stroke.

Example.—Let the steam in the boiler of an engine equal 45 lbs. per inch, the length of stroke 4 feet, and the steam to be shut off after the piston has moved 16 inches; required an equivalent force of steam in the cylinder.

4 feet = 48 inches, and 48 ÷ 16 = 3.
Then, 45 ÷ 3 = 15 lbs. And, 1 + 1.0986123 = 2.0986123 × 15 = 31.4791845 lbs. uniform force of the steam.

HYPERBOLIC LOGARITHMS.

No.	Log.	No.	Log.	No.	Log.	No.	Log.
1¼	.2231435	3¼	1.1786549	5¼	1.6582280	7¼	1.9810014
1½	.4054651	3½	1.2527629	5½	1.7047481	7½	2.0149030
1¾	.5596157	3¾	1.3217558	5¾	1.7491998	7¾	2.0476928
2	.6931472	4	1.3862943	6	1.7917594	8	2.0794415
2¼	.8109302	4¼	1.4469189	6¼	1.8325814	8½	2.1400661
2½	.9162907	4½	1.5040774	6½	1.8718021	9	2.1972245
2¾	1.0116008	4¾	1.5581446	6¾	1.9095425	9½	2.2512917
3	1.0986123	5	1.6094379	7	1.9459101	10	2.3025851

THE STEAM WAY.

Multiply any cylinder's area by .034, and the product will be the area of port or steam way.

Example.—What area of port or steam way is necessary for a cylinder 36 inches diameter?

36 inches diameter = 1017.8 inches area × .034 = 34.6 inches area of steam way.

OF THE SLIDE VALVE.

When the valve is at the middle of its stroke, the faces ought to cover the apertures on the exhausting side about $\frac{1}{10}$ of an inch; the cover on the steam side being for the purpose of cutting off the steam at any part of the stroke, is, therefore, at the entire discretionary judgment of the engineer. However, we find from practice, that high-pressure engines with short strokes, as locomotives, &c., require no more than will cover the apertures properly; whereas condensing engines, with steam of $2\frac{1}{2}$ to 3 lbs. per square inch, will work well with $\frac{5}{8}$ of an inch cover on the steam side; and marine engines give great satisfaction with $1\frac{3}{8}$ inches cover, when the steam is $4\frac{1}{2}$ lbs. to 5 lbs. per square inch.

Again, the lead of the valve (as it is termed amongst engineers) is a certain distance that the extremity of the eccentric must be in advance of the crank, so that the valve may be open as required when the piston is at the top or bottom of the cylinder,—for this reason, that, at the return of the stroke, the steam in the cylinder may be of, or nearly, an equal density with the steam in the boiler; consequently, the nearer that the length of the aperture is to the area of the cylinder, the less lead is required. Thus,

Suppose a cylinder of 48 inches diameter, with an aperture 16 inches long, $\frac{48^2}{16} = 144$; and another 24 inches diameter, with an aperture 8 inches long, $\frac{24^2}{8} = 72$; then $\frac{144}{72} = 2$. Hence it is evident that, although both apertures bear the same proportion to the diameter of the cylinder, and both valves move the same distance, the 48 inch cylinder would be twice the time in filling with steam to that of the 24 inch, for a cylinder twice the diameter is four times the area; but scarcely two engineers agree upon this point. However, the following is an approximate rule to a number

of celebrated working engines, namely: Multiply the square of the cylinder's diameter in inches by .002, and divide the product by the length of the aperture, also in inches; the quotient will be the width that the valve must be open when the piston is exactly at the top or bottom of the cylinder.

Example.—Let a cylinder be 30 inches diameter, with an aperture 12 inches long.

$$\frac{30^2 \times .002}{12} = .15 \text{ parts of an inch for the aper-}$$

ture to be open at the return of the stroke.

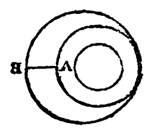
THE ECCENTRIC.

1.—The length of the levers on the weigh or traverse shaft given, to find the required throw of the eccentric.

Rule.—Multiply the distance that the valve is to travel by the length of the lever on the weigh shaft for the eccentric rod; divide the product by the length of the lever for working the valve, and the quotient is the throw of the eccentric.

Example.—Let a valve be required to travel 6 inches, the lever on the weigh shaft for working the valve 12 inches in length, and the lever for the eceentric rod 10 inches; required the throw of that eccentric.

$$\frac{6 \times 10}{12} = 5 \text{ inches throw.}$$



The throw of the eccentric is the distance between A and B on that eccentric.

2.—The throw of the eccentric and the stroke of the valve, also one of the levers on the weigh shaft given, to find the other.

Rule.—Multiply the throw of the eccentric by the length of the lever to work the valve, and divide by the distance the valve is to travel; the quotient will be the length of the other lever. Or,

Multiply the travel of the valve by the length of the lever on the weigh shaft, for the eccentric rod, and divide by the throw of the eccentric; the quotient will be the length of the lever for working the valve.

Example.—Suppose a valve be required to travel 6 inches, the throw of the eccentric 5, and the length of the lever on the weigh shaft for working equal 12 inches; required the length of the other.

$$\frac{5 \times 12}{6} = 10 \text{ inches; or}$$

$$\frac{6 \times 10}{5} = 12 \text{ inches.}$$

THE COLD WATER PUMP.

Taking practice as a data whereby to determine the quantity of water sufficient for condensation in all ordinary cases of the steam engine, I find that, at the common temperature of the atmosphere, four imperial gallons of water to each horse power are quite capable of condensing steam at 220° Faht. to water at 80°; but if the temperature of the steam be raised, the quantity of water must be augmented, according to the result of the following

Rule.—Multiply the temperature of the steam in the boiler by .019, and the product will be the quantity required in imperial gallons per minute to each horse power. Hence, to find the diameter of the pump, when the stroke is given, or the stroke of the pump, when the diameter is given,

Multiply the quantity required in gallons for each horse power by the number of horses' power that the engine is equal to, and by 353; divide the product by the intended stroke of the pump in inches multiplied by the number of strokes per minute, and the square root of the quotient is the pump's diameter in inches.—

Or, divide the product by the number of strokes per minute multiplied by the square of the pump's diameter, and the quotient is the length of the stroke.

Example.—Let an engine of 25 horses' power be propelled by steam at 7 lbs. per square inch, what must be the pump's diameter when the stroke is 23 inches, and making 22 strokes per minute?

7 lbs. per square inch = 234°; and

$234 \times .019 = 4.446$ gallons to each horse power.

Then $\frac{4.446 \times 25 \times 353}{23 \times 22} = \sqrt{77.54} = 8.8$ inches diameter nearly.

Or, $\frac{4.446 \times 25 \times 353}{77.54 \times 22} = 23$ inches length of stroke.

Note.—The diameter of the injection cock ought to be at least equal to $\frac{1}{12}$th of the cylinder's diameter.

To find the necessary quantity of water for a boiler.

Rule.—Add 15 to the pressure on each square inch of the boiler in lbs., divide the sum by 18, multiply the quotient by .2, and the product is the quantity in imperial gallons per minute for each horse power. Hence, the rule for the cold water pump is also applicable for the hot water pump.

Example.—Suppose a 6 horse engine to be propelled by steam at 30 lbs. per square inch, stroke of pump 9 inches, and making 45 strokes per minute, required the pump's diameter.

$\frac{30 + 15}{18} = 2.5 \times .2 = .5$ of a gallon per minute to each horse power.

Then $\frac{.5 \times 6 \times 353}{45 \times 9} = \sqrt{2.6} = 1.6$ inches diameter, nearly.

Or, $\frac{.5 \times 6 \times 353}{45 \times 2.6} = 9$ inches length of stroke.

THE AIR PUMP.

The *Air Pump* for a land engine generally requires to be larger in proportion to the cylinder than the air pump for a marine engine, on account of having frequently to condense with water at a higher temperature; hence, when the stroke of the bucket is half the stroke of the piston, multiply the cylinder's diameter in inches by .67, and the product is the diameter of air pump.—Again, multiply the diameter of the cylinder of a marine engine, in inches, by .575, and the product is the diameter of air pump,

EXAMPLE.—What diameter of air pump is requisite for an engine whose cylinder is 28 inches diameter?

$$28 \times .67 = 18.76 \text{ inches diameter.}$$

When the stroke of the bucket is either more or less than half the stroke of the piston, the pump's diameter will then be obtained by the following

RULE.—Square the given diameter, multiply by the length, and divide by the length proposed, extract the square root, and the product will be the diameter.

EXAMPLE.—Suppose an engine with a 4 feet stroke required an air pump 26 inches diameter with a 2 feet stroke, but necessity requires it to be 6 inches nearer the end of the beam, what must be the diameter of air pump, the beam being 11 feet long?

Radius of beam = 66 inches. Then,

As $66 : 48 :: 39 : 28.36$ inches, length of stroke;

And $\sqrt{\dfrac{26^2 \times 24}{28.36}} = 24$ inches, diameter of pump nearly.

The *Condenser* ought to be a little more in capacity than the air pump; but in the case of marine engines, where the bottom of the condenser and bottom of the cylinder are nearly on a level, care must be taken to make the passage between the valves and condenser large enough to contain the condensing water required

for one stroke of the piston, besides leaving a proper communication, otherwise the connexion between the cylinder and condenser will be cut off by water of nearly 100° of heat, on account of the cylinder being twice filled with steam for each effective stroke of the air pump.

The area of air pump multiplied by .25 will give the area of foot and discharging valves; thus, 24 inches diameter = 452.39 inches area, × .25 = 113.0975 inches, area of valves.

The piston rod is about $\frac{1}{10}$ of the cylinder's diameter; the air pump rod in the same proportion, unless it be made of copper, and then it may be about $\frac{1}{8}$ of the pump's diameter.

THE BEAM.

When a beam is applied to an engine its length ought not to be less than three times the length of the stroke. and its breadth half the stroke, or in high pressur engines $\frac{2}{5}$ of the stroke; also its best form is a parabol

To find the thickness of a beam, when the length, breadt and diameter of the cylinder are given.

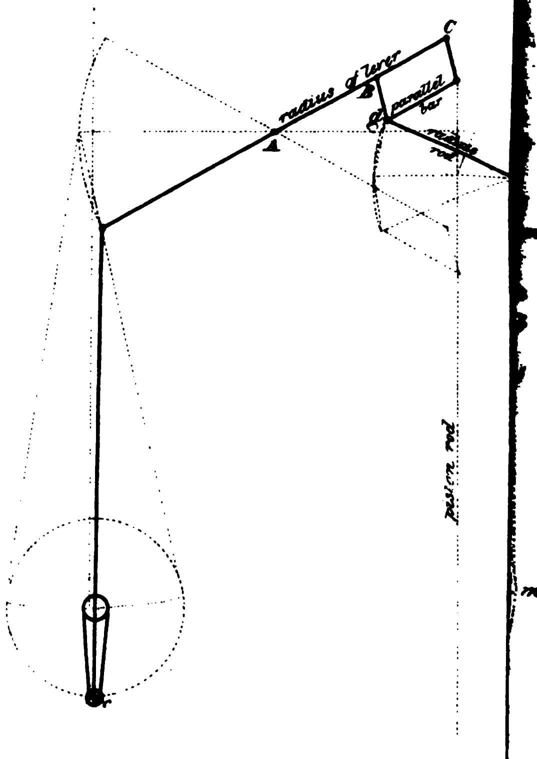
Rule.—Multiply the whole pressure of steam the piston in lbs. by half the length of the beam in fe and divide the product by 70 times the square of t breadth in inches, and the quotient will be the thi ness in inches nearly.

Example.—What thickness of beam is requisit an engine whose cylinder is 25 inches diameter, length of the beam being 15 feet, length of stroke 5 and the effective pressure on each square inch o piston equal 15 lbs.

Area of piston = 490.875 inches.

And $\frac{490.875 \times 15 \times 7.5}{30^2 \times 70} = .876$ or $\frac{7}{8}$ of an i thickness nearly.

Fig 1st A motion that is generally applied to land Engines &c.



To find the versed sine of the arc described by the beam of an engine.

RULE.—Divide the square of half the length of the stroke in inches, by the length of the beam also in inches, and the quotient is the versed sine.

EXAMPLE.—Required the versed sine of the arc described by an engine beam 12 feet in length, the chord of the arc or length of the stroke being 4 feet.

$$\frac{24^2}{144} = 4 \text{ inches the versed sine.}$$

NOTE.—When the beam is not equal lengths at each end from the centre on which it vibrates, the length is then to be taken equal to twice the radius of that end of which the versed sine is required.

THE PARALLEL MOTION.

The beam being given, to find the length of the radius rods.

RULE.—Divide the square of the distance between A and B, on the beam, by the distance between B and C, and the quotient is the length of the radius rod $d\ x$.

FIG. 1, EXAMPLE.—Suppose a beam 12 feet long, and the stud for the back links 39 inches from the centre, required the length of radius rods.

Radius of beam $= 72$ inches, and $72 - 39 = 33$

then $\frac{39^2}{33} = 46.09$ inches.

NOTE.—The length of the front and back links equal half the length of the stroke.

FIG. 2, EXAMPLE.—Suppose $b\ d = 32\frac{1}{4}$, and $d\ a = 35\frac{1}{4}$, to find d F.

$$\frac{32.25^2}{35.25} = 29.5 \text{ inches nearly.}$$

FIG. 3.—As the calculation of this motion is rather tedious, on account of the various angles formed by the

side rods, it is considered better to lay it down in the following geometrical form:—

Upon the line A *m*, with the radius of the beam, describe the arc *b m t*; from *m*, with half the length of stroke, cut the arc in *b* and *t*, draw the line *b t* and *r m* equal the versed sine described by the beam; bisect *r m* in *n*, and erect a perpendicular line for the centre of the cylinder. Again, from *b m t*, with the length of the side rods, cut the perpendicular line; at the bottom, middle, and top stroke of the cross-head draw the lines *b b*, *m m*, *t t*; from the end of the cross-head, or top of the side rods, with any convenient distance, set off the pin or stud in the side rod for the end of the parallel bar 1, 2, 3, from which, with the distance *s t*, describe arcs at *d* D *d*; draw the lines *d* 1, D 2, &c. Then the length of the crank may be found either by the sixth problem in Geometry, or the eighth problem in Mensuration.

THE CONNECTING ROD.

The proportionate length of connecting rod is three times the length of stroke, which determines the perpendicular distance between the centre of the beam and centre of fly-wheel shaft. Or, if the engine is erected, the length of connecting rod is the perpendicular distance between the centre of the fly-wheel shaft and centre of the beam.

THE FLY WHEEL.

To find the weight of the rim or ring of a fly-wheel proper for a steam engine.

RULE.—Multiply the constant number, 1368, by the number of horses' power that the engine is equal to; divide the product by the diameter of the wheel, in feet, multiplied by the number of revolutions per minute; and the quotient is the weight of the ring in cwts. nearly.

EXAMPLE.—Required the weight of the rim of a fly-wheel proper for an engine of 20 horses' power, the

wheel to be 16 feet diameter, and make 21 revolutions per minute.

$$\frac{1368 \times 20}{16 \times 21} = 81.4 \text{ cwt. nearly.}$$

NOTE.—The fly-wheel of an engine for a corn or flour mill ought to be of such a diameter that the velocity of the periphery of the wheel may exceed the velocity of the periphery of the stones, to prevent, as much as possible, any tendency to back lash, as it is termed.

The necessary weight and diameter of the wheel being found, suppose a breadth of rim, and the thickness to make the weight in cast iron will be found by the following

RULE.—Divide the required weight in lbs. by the area of the ring in inches, multiplied by .263, and the quotient is the thickness of the ring in inches.

EXAMPLE.—What thickness must a ring be to equal 81.4 cwts. when the outer diameter is 16 feet, and the inner diameter 14 feet 8 inches?

81.4 cwts. = 9116.8 lbs.

And, by Problem XII in Mensuration, the area of the ring = 4624.43 inches.

Then, $$\frac{9116.8}{4624.43 \times 263} = 7.496 \text{ inches nearly.}$$

And if the ring is to be of a cylindrical form, find the diameter of a circle, (by Problem IX in Mensuration,) having the same area as the cross-section of the ring found.

Thus, suppose the ring, in the last example, be required to be cylindrical,—Required its cross-sectional diameter to equal 81.4 cwts., the diameter of the wheel being 16 feet.

$7.496 \times 8 = 59.968$ inches cross-sectional area of the ring found.

And $$\sqrt{\frac{59.968 \times 452}{355}} = 8.73 \text{ inches diameter nearly.}$$

Or, as an approximate, multiply the required weight, in lbs., by 1.62; divide the product by the diameter of the wheel, in inches, and the square root of the quotient will be the diameter of the cross-section of the ring, in inches, nearly.

Thus, $\sqrt{\dfrac{9116.8 \times 1.62}{16 \times 12}} = 8.77$ inches.

Sometimes (for various reasons) it is necessary to have the fly-wheel upon a second mover; for instance, there is a 6 horse engine making 50 revolutions per minute, having a fly-wheel of 7 ft. diameter, and 9 cwt., but, by the rule, it ought to be 23.46 cwt. Now, a larger wheel cannot be got in, but the same may be put upon a second motion,—required the velocity that will increase its momentum equal to 23.46 cwt. on the first motion.

7 feet diameter $=$ 21.9912 feet circumference, and 21.9912×50 revolutions $=$ 1099.56 feet velocity.

Cwt. *Velocity.* *Cwt.* *Velocity.*

Then, as $9 : 1099.56 :: 23.46 : 2866.1864 \div 21.9912$ $=$ 130 revolutions per minute nearly.

To find the centrifugal force of a fly-wheel.

Rule.—Multiply the decimal .6136 by the diameter of the wheel in feet, and divide the product by the square of the time of one revolution; the quotient will be the centrifugal force when the weight of the body is 1.

Example.—Required the centrifugal force of a fly-wheel 15 feet diameter, and making 40 revolutions per minute, the weight of the ring being 3 tons,

$60 \div 40 = 1.5$, time of one revolution.

And $\dfrac{.6136 \times 15}{1.5^2} = 4.09 \times 3 = 12.27$ tons, the centrifugal force.

The centre of percussion in a fly-wheel, or wheels in general, is $\frac{3}{4}$ distant from the centre of suspension nearly.

NOTE.—The centrifugal force is that power or tendency which all revolving bodies have to burst, or fly asunder in a direct line.

And the centre of percussion in a revolving body is that point where the whole force or motion is collected, or that point which would strike any obstacle with the greatest effect.

THE GOVERNOR OR REGULATOR.

The length of pendulums given, to find the number of revolutions per minute.

RULE.—Divide 375 by the square root of the pendulum's length, and half the quotient will be the velocity required.

EXAMPLE.—What number of revolutions ought a governor to make per minute whose pendulums are 24 inches long?

$$\frac{375}{\sqrt{24}} = 76 \div 2 = 38 \text{ revolutions per minute.}$$

The revolutions per minute of a governor given, to find the length of pendulums.

RULE.—Divide 375 by twice the number of revolutions per minute, and the square of the quotient will be the length required.

EXAMPLE.—When the velocity of a governor is 38 revolutions per minute, what ought to be the length of pendulums?

$38 \times 2 = 76$, and $\frac{375}{76} = 4.93^2 = 24.3049$ inches nearly.

OF HIGH PRESSURE ENGINES.

High pressure engines, in general, (if in good condition,) will work when the force of the steam is about 4 lbs. per circular inch,—that is, 4 lbs. on each circular inch of the piston will overcome the resistance and friction of the engine itself, divested of machinery, &c. Hence the rule.

1. From the pressure in lbs. on each circular inch of the boiler deduct 4 lbs.; multiply the remainder by the square of the cylinder's diameter in inches, and by the velocity of the piston in feet per minute; divide the product by 33000, and the quotient will be the force of the engine expressed in horses' power.

Example.—Suppose a cylinder 8 inches diameter, stroke 2 feet, making 45 revolutions per minute, or 180 feet, and steam 23.5 lbs. per circular inch, required the power.

$$23.5 - 4 = \frac{19.5 \times 8^2 \times 180}{33000} = 6.8 \text{ horses'}$$

power nearly.

2. Multiply 33000 by the number of horses' power required, and divide the product by the velocity of the piston in feet per minute, multiplied by the force of the steam in lbs. on each circular inch of the boiler, minus 4 lbs., and the square root of the quotient is the cylinder's diameter in inches.

Example.—Required the diameter of the cylinder for an engine of 6.8 horses' power, when the stroke is 2 feet, and making 45 strokes per minute, the force of the steam being 23.5 lbs. per circular inch.

$$\frac{33000 \times 6.8}{180 \times 23.5 - 4} = \sqrt{64} = 8 \text{ inches diameter.}$$

Note.—There is always a resistance of steam on the piston of a high pressure or non-condensing engine equal to the pressure of the atmosphere, but this cannot be taken into account, unless we also take into account the pressure of the atmosphere upon the boiler.

MISCELLANIES.

Approximate rules for finding the weight of round, square, and rectangular beams, bars, &c., of cast and wrought iron.

RULE 1.—Multiply the square of the diameter in inches by the length in feet, and by 2.6 for wrought iron, or 2.48 for cast iron, and the product will be the weight in pounds avoirdupois nearly.

2.—Multiply the area of the cross section in inches by the length in feet, and by 3.32 for wrought iron, or 3.16 for cast iron, and the product will be the weight in pounds avoirdupois nearly.

EXAMPLE 1.—Required the weight of a round bar of wrought iron 14 feet long and $2\frac{1}{2}$ inches diameter.

$$2.5^2 \times 14 = 87.50 \times 2.6 = 227.5 \text{ lbs.}$$

EXAMPLE 2.—The length of a piece of cast iron is $9\frac{1}{2}$ feet, its breadth 7 inches, and thickness $2\frac{1}{4}$, required its weight.

$$2.25 \times 7 = 15.75 \times 9.5 = 149.625 \times 3.16 = 472.815 \text{ lbs.}$$

The dimensions of a cast iron ring being given, to find its weight nearly.

RULE.—Multiply the breadth of the ring added to the inner diameter by .0074, and that again by the breadth and by the thickness, and the product will be its weight in cwts. nearly.

EXAMPLE.—Required the weight of a ring whose dimensions are 8 feet 4 inches, interior diameter 5 inches broad and 4 inches thick.

Inches.

$$8 \text{ feet } 4 \text{ inches} = 100 + 5 = 105 \times .0074 = .777 \times 5 = 3.885 \times 4 = 15.52 \text{ cwts. nearly.}$$

To find the weight of any cast iron ball whose diameter is given.

RULE.—Multiply the cube of the diameter in inches by .1377, and the product will be the weight in avoirdupois pounds nearly.

EXAMPLE.—Required the weight of a ball 7 inches diameter.

$$7^3 = 343 \times .1377 = 47.2211 \text{ lbs.}$$

To find the diameter of a cast iron ball when the weight is given.

RULE.—Multiply the cube root of the weight in pounds by 1.936, and the product will be the diameter in inches nearly.

EXAMPLE.—Required the diameter of a ball that will weigh 64 pounds.

$$\sqrt[3]{64} = 4 \times 1.936 = 7.744 \text{ inches diameter.}$$

TABLE

Containing the weight of a square foot of copper and lead, in lbs. avoirdupois, from $\frac{1}{32}$ to $\frac{1}{2}$ an inch in thickness, advancing by $\frac{1}{32}$.

Thickness.	Copper.	Lead.
$\frac{1}{32}$	1.45	1.85
$\frac{1}{16}$	2.90	3.70
$\frac{3}{32}$	4.35	5.54
$\frac{1}{8}$	5.80	7.39
$\frac{1}{8}$ & $\frac{1}{32}$	7.26	9.24
$\frac{1}{8}$ & $\frac{1}{16}$	8.71	11.08
$\frac{1}{8}$ & $\frac{3}{32}$	10.16	12.93
$\frac{1}{4}$	11.61	14.77
$\frac{1}{4}$ & $\frac{1}{32}$	13.07	16.62
$\frac{1}{4}$ & $\frac{1}{16}$	14.52	18.47
$\frac{1}{4}$ & $\frac{3}{32}$	15.97	20.31
$\frac{3}{8}$	17.41	22.16
$\frac{3}{8}$ & $\frac{1}{32}$	18.87	24.00
$\frac{3}{8}$ & $\frac{1}{16}$	20.32	25.85
$\frac{3}{8}$ & $\frac{3}{32}$	21.77	27.70
$\frac{1}{2}$	23.22	29.55

TABLE

Of the weight of a square foot of sheet iron in lbs. avoirdupois, the thickness being the number on the wire gauge.—No. 1 is $\frac{5}{16}$ of an inch; No. 4, $\frac{1}{4}$; No. 11, $\frac{1}{8}$, &c.

No. on wire gauge	1	2	3	4	5	6	7	8	9	10	11
Pounds avoir......	12.5	12	11	10	9	8	7.5	7	6	5.68	5
No. on wire gauge	12	13	14	15	16	17	18	19	20	21	22
Pounds avoir......	4.62	4.31	4	3.95	3	2.5	2.18	1.93	1.62	1.5	1.37

TABLE

Of the weight of a square foot of boiler plate iron, from $\frac{1}{8}$ to 1 inch thick, in lbs. avoirdupois.

$\frac{1}{8}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$	1 in
5	7.5	10	12.5	15	17.5	20	22.5	25	27.5	30	32.5	35	37.5	40

TABLE

Of the weight of solid cylinders of cast iron, 12 inches long, in lbs. avoirdupois.

Dmr. Inch.	Weight in lbs.	Dmr. Inch.	Weight in lbs.	Dmr. Inch.	Weight in lbs.	Dmr. Inch.	Weight in lbs.	Dmr. Inch.	Weight in lbs.
3/4	1.394	2 1/8	11.193	3 1/2	30.364	5 3/4	81.952	9	200.774
7/8	1.897	2 1/4	12.548	3 5/8	32.572	6	89.234	9 1/2	223.704
1 in.	2.478	2 3/8	13.981	3 3/4	34.857	6 1/4	96.825	10	247.872
1 1/8	3.137	2 1/2	15.492	3 7/8	37.219	6 1/2	104.726	10 1/2	273.278
1 1/4	3.873	2 5/8	17.080	4	39.660	6 3/4	112.936	11	299.925
1 3/8	4.686	2 3/4	18.745	4 1/4	44.771	7	121.457	11 1/2	327.811
1 1/2	5.577	2 7/8	20.488	4 1/2	50.193	7 1/4	130.287	12	356.935
1 5/8	6.545	3	22.308	4 3/4	55.926	7 1/2	139.428	13	418.903
1 3/4	7.591	3 1/8	24.206	5	61.968	7 3/4	148.878	14	485.830
1 7/8	8.714	3 1/4	26.181	5 1/4	68.319	8	158.638	15	557.712
2	9.915	3 3/8	28.234	5 1/2	74.981	8 1/2	179.087	16	634.552

Cubic inches of cast iron multiplied by .263 = lbs. avoirdupois.

Circular inches of cast iron multiplied by .2065 = lbs. avoirdupois.

TABLE

For finding the weight of malleable iron, copper, and lead pipes, 12 inches long, of various thicknesses, and any diameter required.

Thickness.	Mall. Iron.	Copper.	Lead.
1/32 of an inch.	.104	.121	.1539
1/16	.208	.2419	.3078
3/32	.3108	.3628	.4616
1/8	.414	.4838	.6155
1/8 & 1/32	.518	.6047	.7694
1/8 & 1/16	.621	.7258	.9232
1/8 & 3/32	.725	.8466	1.0771
1/4	.828	.9678	1.231

RULE.—Multiply the circumference of the pipe in inches by the numbers opposite the thickness required, and by the length in feet; the product will be the weight in avoirdupois lbs. nearly.

EXAMPLE.—Required the weight of a copper pipe 12 feet long, 15 inches in circumference, 1/8 and 1/16 of an inch in thickness.

$.7258 \times 15 = 10.817 \times 12 = 130.644$ lbs. nearly.

TABLE

Containing the weight of wrought iron bars 12 inches long in lbs. avoirdupois.

Inch.	Round.	Square.	Inch.	Round.	Square.
1/4	.163	.208	2 1/2	16.32	20.80
3/8	.367	.467	2 5/8	18.00	22.89
1/2	.653	.830	2 3/4	19.76	25.12
5/8	1.02	1.30	2 7/8	21.59	27.46
3/4	1.47	1.87	3	23.52	29.92
7/8	2.00	2.55	3 1/4	27.60	35.12
1	2.61	3.32	3 1/2	32.00	40.80
1 1/8	3.31	4.21	3 3/4	36.72	46.72
1 1/4	4.08	5.20	4	41.76	53.12
1 3/8	4.94	6.28	4 1/4	47.25	60.00
1 1/2	5.88	7.48	4 1/2	52.93	67.24
1 5/8	6.90	8.78	4 3/4	58.92	74.95
1 3/4	8.00	10.20	5	65.28	83.20
1 7/8	9.18	11.68	5 1/4	72.00	91.56
2	10.44	13.28	5 1/2	79.04	100.48
2 1/8	11.80	15.00	5 3/4	86.36	109.82
2 1/4	13.23	16.81	6	94.08	119.68
2 3/8	14.73	18.74	7	128.00	163.20

TABLE

Of the proportional dimensions of 6-sided nuts for bolts, from 1/4 to 2 1/2 inches diameter.

Diameter of bolts	1/4	3/8	1/2	5/8	3/4	7/8	1	1 1/8	1 1/4
Breadth of nuts	11/16	13/16	1	1 3/16	1 3/8	1 9/16	1 3/4	1 15/16	2 1/8
Breadth over the angles	3/4	15/16	1 1/8	1 3/8	1 9/16	1 13/16	2	2 1/4	2 7/16
Thickness	5/16	7/16	9/16	3/4	7/8	1	1 1/8	1 1/4	1 7/16
Diameter of bolts	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	2	2 1/4	2 1/2	
Breadth of nuts	2 5/16	2 1/2	2 11/16	2 7/8	3 1/16	3 1/4	3 5/8	4	
Breadth over the angles	2 11/16	2 7/8	3 1/8	3 5/16	3 1/2	3 3/4	4 3/16	4 5/8	
Thickness	1 9/16	1 11/16	1 13/16	2	2 1/8	2 1/4	2 1/2	2 3/4	

TABLE

Of the weight of flat bar iron, 12 inches long, in lbs. avoirdupois.

Breadth in inches. / Thickness	⅛	3/16	¼	⅜	½	⅝	¾	⅞	1 inch.
½	.21	.31	.42	.63					
¾	.31	.47	.63	.94	1.26	1.57			
1	.42	.63	.84	1.26	1.68	2.10	2.52	2.94	
1¼	.52	.78	1.05	1.57	2.10	2.62	3.15	3.67	4.20
1⅜	.57	.86	1.18	1.73	2.31	2.88	3.46	4.04	4.62
1½	.63	.94	1.26	1.89	2.52	3.15	3.78	4.41	5.04
1¾	.73	1.10	1.47	2.20	2.94	3.67	4.41	5.14	5.87
2	.84	1.26	1.68	2.52	3.36	4.20	5.06	5.88	6.72
2¼	.96	1.41	1.89	2.83	3.78	4.72	5.66	6.61	7.56
2½	1.05	1.57	2.10	3.15	4.20	5.25	6.30	7.35	8.40
2¾	1.15	1.73	2.31	3.46	4.62	5.77	6.93	8.08	9.24
3	1.26	1.89	2.52	3.78	5.04	6.30	7.56	8.82	10.08
3¼	1.36	2.04	2.73	4.09	5.46	6.82	8.19	9.55	10.92
3½	1.47	2.20	2.94	4.41	5.88	7.35	8.82	10.29	11.76
3¾	1.57	2.36	3.15	4.72	6.30	7.87	9.45	11.02	12.60
4	1.68	2.52	3.36	5.04	6.72	8.40	10.08	11.76	13.44
4½	1.89	2.83	3.78	5.67	7.56	9.45	11.34	13.23	15.12
5	2.10	3.15	4.12	6.30	8.40	10.50	12.60	16.70	17.80
6	2,52	3.78	5.04	7.56	10.08	12.60	15.12	17.64	20.16

Weight of a copper rod 12 inches long and 1 inch diameter = 3.039 lbs.

Weight of a brass rod 12 inches long and 1 inch diameter = 2.86 lbs.

TABLE

Of the specific gravity of water at different temperatures, that at 62° being taken as unity.

70°F.	.99913	52°F.	1.00076
68	.99936	50	1.00087
66	.99958	48	1.00095
64	.99980	46	1.00102
62	1.	44	1.00107
58	1.00035	42	1.00111
56	1.00050	40	1.00113
54	1.00064	38	1.00115

The difference of temperatures between 62° and 92° where water attains its greatest density, will vary th bulk of a gallon rather less than the third of a cubic inch.

TABLE

Of the weight of cast iron pipes 12 *inches long, in lbs. avoirdupois.*

Diam. of bore.	Thickness of Metal.						
	¼	⅜	½	⅝	¾	⅞	1
Inch.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
1½	4.3	6.9	9.9				
2	5.5	8.8	12.3				
2½	......	10.6	14.8	19.3			
3	......	12.5	17.3	22.4			
3½	......	14.4	19.8	25.5			
4	......	......	22.3	28.6	35.3		
4½	......	......	24.7	31.7	39		
5	......	......	27.2	34.8	42.7		
5½	......	......	29.7	37.7	46.4		
6	......	......	......	41	50.2	59.6	
6½	......	......	......	44.2	54	64	
7	......	......	......	47.2	57.2	68.3	
7½	......	......	......	50.3	61.3	72.6	
8	......	......	......	......	65	77	89
8½	......	......	......	......	68.7	81.3	94.2
9	......	......	......	......	72.5	85.6	99.1
9½	......	......	......	......	76.2	90	104
10	......	......	......	......	79.9	94.3	109
10½	......	......	......	......	83.6	98.6	114
11	......	......	......	......	87.3	103	119
11½	......	......	......	......	91.1	107.3	124
12	......	......	......	......	94.8	111.7	129

NOTE.—The first column is the width of the pipes, expressed in inches and parts of an inch; and the remaining columns are the weights of the pipes, under the different thicknesses in which they are placed.

N.B.—Two flanges are generally reckoned equal to one foot of pipe.

TABLE

Of the weight of a square foot of millboard, in lbs. avoirdupois.

Thickness in inches.........	⅛	3/16	¼	5/16	⅜
Weight in lbs................	.688	1.032	1.376	1.72	2.064

TABLE

Of the weight of cast iron balls, in pounds avoirdupois, from 1 *to* 12 *inches diameter, and advancing by an eighth.*

Inches.	Lbs. & Parts.	Inches.	Lbs. & Parts.	Inches.	Lbs. & Parts.
1	.14	4¾	14.76	8½	84.56
1⅛	.20	4⅞	15.95	8⅝	88.34
1¼	.27	5	17.12	8¾	92.24
1⅜	.37	5⅛	18.54	8⅞	96.26
1½	.47	5¼	19.93	9	100.39
1⅝	.59	5⅜	21.39	9⅛	104.62
1¾	.74	5½	22.91	9¼	108.98
1⅞	.91	5⅝	24.51	9⅜	113.46
2	1.10	5¾	26.13	9½	118.06
2⅛	1.32	5⅞	27.91	9⅝	122.77
2¼	1.57	6	29.72	9¾	127.63
2⅜	1.84	6⅛	31.64	9⅞	132.60
2½	2.15	6¼	33.62	10	137.71
2⅝	2.49	6⅜	35.67	10⅛	142.91
2¾	2.86	6½	37.80	10¼	148.28
2⅞	3.27	6⅝	40.10	10⅜	153.78
3	3.72	6¾	42.35	10½	159.40
3⅛	4.20	6⅞	44.74	10⅝	165.16
3¼	4.72	7	47.21	10¾	171.05
3⅜	5.29	7⅛	49.79	10⅞	177.10
3½	5.80	7¼	52.47	11	183.29
3⅝	6.56	7⅜	55.23	11⅛	189.60
3¾	7.26	7½	58.06	11¼	196.10
3⅞	8.01	7⅝	60.04	11⅜	202.67
4	8.81	7¾	64.09	11½	209.43
4⅛	9.67	7⅞	67.25	11⅝	216.32
4¼	10.57	8	70.49	11¾	223.40
4⅜	11.53	8⅛	73.85	11⅞	230.57
4½	12.55	8¼	77.32	12	237.94
4⅝	13.62	8⅜	80.88		

TABLE

Containing some of the properties of various bodies.

Names of Bodies.	Melting and boiling points.	Contracts in cooling in parts of an inch, for each foot in length.	Expands in heating from 32 to 212 deg. of Fahrenheit the length being 1.00000.	Power of conducting heat.
Cast iron melts	17977°	.124	.00111	1.2
Wrought iron welding hot	12780	.137	.00122	1.1
Copper melts..	4587	.193	.00172	1.0
Brass melts ..	3807	.210	.00187	1.0
Steel red hot...	1077	.133	.00118	
Zinc melts ...	700	.329	.00294	
Mercury boils	660		.01851	
Lead melts ...	594	.319	.00286	2.5
Bismuth melts	476	.156	.00139	
Tin melts	442	.278	.00248	1.7
Water boils ...	212		.04002	

TABLE

Showing the expansion of water by heat.

Temperature.	Expansion.	Temperature.	Expansion.
12°F.	1.00236	122°.F	1.01116
22	1.00090	132	1.01367
32	1.00022	142	1.01638
42	1.	152	1.01934
52	1.00021	162	1.02245
62	1.00083	172	1.02575
72	1.00180	182	1.02916
82	1.00312	192	1.03265
92	1.00477	202	1.03634
102	1.00672	212	1.04012
112	1.00880		

Proportions of cement for cast iron.

In mixing cement for cast iron, put one ounce of sal ammoniac to each hundred weight of borings, and use it without allowing it to heat. Multiply the length of any joint in feet by the breadth in inches, by the thickness in eighths, and by .3; the product will be the weight of dry borings, in lbs. avoirdupois, required to make cement to fill that joint nearly.

TABLE

Of boiling points of water holding various proportions of salt in solution.

	Parts of Salt.	Degrees of Faht.	Degrees of Reau.	Degrees of Cent.
Saturated solution	36.37	2266	86.2	107.8
	33.34	224.9	85.7	107.2
	30.30	223.7	85.2	106.5
	27.28	222.5	84.7	105.8
	24.25	221.4	84.1	105.2
	21.22	220.2	83.6	104.6
	18.18	219	83	103.9
	15.15	217.9	82.6	103.3
	12.12	216.7	82.1	102.6
	9.09	215.5	81.6	102
	6.06	214.4	81.1	101.3
Sea water	3.03	213.2	80.5	100.7
Common water	0.00	212	80	100

To reduce any number of degrees of temperature on Fahrenheit's scale to the number of degrees of an equal temperature on Reaumer's scale; and also to the number of degrees of an equal temperature on the Centigrade scale or otherwise.

1.—*Above the freezing point.*

Any number of degrees of Fahrenheit minus 32, multiplied by 4, and divided by 9, = Reaumer.

$$\text{Thus, } \overset{\text{F.}}{77} - 32 = 45, \text{ and } \frac{45 \times 4}{9} = \overset{\text{R.}}{20}$$

$$\text{Or, } \frac{\overset{\text{R.}}{20} \times 9}{4} = 45, \text{ and } 45 + 32 = \overset{\text{F.}}{77}$$

2.—*Below the freezing point.*

Any number of degrees of Fahrenheit plus 32, multiplied by 4, and divided by 9, = Reaumer.

$$\text{Thus, } \overset{\text{F.}}{22} + 32 = 54, \text{ and } \frac{54 \times 4}{9} = \overset{\text{R.}}{24}.$$

$$\text{Or, } \frac{\overset{\text{R.}}{24} \times 9}{4} = 54, \text{ and } 54 - 32 = \overset{\text{F.}}{22}.$$

3.—*Above the freezing point.*

Any number of degrees of Fahrenheit minus 32 multiplied by 5, and divided by 9, = Centigrade,

$$\text{Thus, } \overset{\text{F.}}{167} - 32 = 135, \text{ and } \frac{135 \times 5}{9} = \overset{\text{C.}}{75}.$$

$$\text{Or, } \frac{\overset{\text{C.}}{75} \times 9}{5} = 135, \text{ and } 135 + 32 = \overset{\text{F.}}{167}.$$

4.—*Below the freezing point.*

Any number of degrees of Fahrenheit plus 32, multiplied by 5, and divided by 9, = Centigrade.

$$\text{Thus, } \overset{\text{F.}}{13} + 32 = 45, \text{ and } \frac{45 \times 5}{9} = \overset{\text{C.}}{25}.$$

$$\text{Or, } \frac{\overset{\text{C.}}{25} \times 9}{5} = 45, \text{ and } 45 - 32 = \overset{\text{F.}}{13}.$$

TABLE

Showing the quantity and weight of a superficial foot of brick work, from half a brick to two and a half bricks in thickness.

Thickness by number.	Thickness in inches.	Number of bricks.	Weight in lbs. avoir.
½ brick	4½	4.58	40.23
1	9	9.15	80.37
1½	14	13.72	120.51
2	18½	18.3	160.74
2½	23½	22.875	200.93

NOTE.—The weight is independent of mortar.

1 Brick weighs 9lbs. avoirdupois nearly; 12½ = 1 cwt., and 250 = 1 ton.

TABLE

Of the specific gravities of those bodies chiefly used in machinery, building, &c., showing, in avoirdupois ounces and pounds, the weight of a cubic foot of each body; also the weight of a cubic inch, and the number of cubic inches in a pound, with multipliers to each, for finding the weight when the dimensions are given.

Names of Bodies.	Weight of a Cubic Foot		Weight of a Cubic In.	No. of Cubic inches in a Pound.	Multipliers.
	oz.	lb.	oz		
Copper, cast........	8788	549.25	5.086	3.146	.3178
Copper, sheet.....	8915	557.18	5.159	3.103	.3225
Brass, cast.........	8396	524.75	4.852	3.293	.3037
Iron, cast...........	7271	454.43	4.203	3.802	.263
Iron, bar............	7631	476.93	4.410	3.623	.276
Lead.................	11344	709.00	6.456	2.437	.4103
Steel, soft..........	7833	489.56	4.527	3.530	.2833
Steel, hard.........	7816	488.50	4.517	3.537	.2827
Zinc, cast...........	7190	449.37	4.156	3.845	.26
Tin, cast............	7292	455.75	4.215	3.790	.2636
Bismuth............	9880	619.50	5.710	2.789	.3585
Gun metal.........	8784	549.00	5.0775	3.147	.3177
Sand................	1520	95.00	.8785	18.190	.055
Coal.................	1250	78.12	.7225	22.120	.0452
Brick	2000	125.00	1.156	13.824	.0723
Stone, paving.....	2416	151.00	1.396	11.443	.0873
Slate	2672	167.00	1.544	10.347	.0967
Marble..............	2742	171.37	1.585	10.083	.0991
White Lead	3160	197.50	1.826	8.750	.1143
Glass................	2880	180.00	1.664	9.600	.1042
Tallow	945	59.06	.5462	29.258	.0342
Cork.................	240	15.00	.138	115.200	.0087
Larch	544	34.00	.315	50.823	.0197
Elm..................	556	34.75	.321	49.726	.0201
Pine, pitch.........	660	41.25	.382	41.890	.024
Beech	696	43.50	.403	39.724	.0252
Teak	745	46.56	.431	37.113	.027
Ash..................	760	47.50	.440	36.370	.0275
Mahogany	852	53.25	.493	32.449	.0308
Oak..................	970	60.62	.561	28.505	.0351
Oil of Turpentine	870	54.37	.503	31.771	.0315
Olive Oil	915	57.18	.529	30.220	.0331
Linseed Oil,.......	932	58.25	.539	29.665	.0337
Spirits, proof......	927	57.93	.536	29.828	.03352
Water, distilled..	1000	62.50	.578	27.648	.03617
Water, sea.........	1028	64.25	.594	26.894	.0372
Tar	1015	63.43	.587	27.242	.0367
Vinegar	1026	64.12	.593	26.949	.037
Mercury	13568	848.00	7.851	2.037	.4908

The 1st, 2d, 3d, and 4th columns require no farther explanation than the titles they bear; the fifth column is to find the weight of any number of cubic inches, in avoirdupois pounds, of any of the different bodies required.

EXAMPLE 1.—Suppose a piece of cast iron to be $56\frac{3}{4}$ inches long, $16\frac{1}{2}$ inches broad, and $\frac{3}{4}$ of an inch in thickness, required its weight.

$56.75 \times 16.5 \times .75 = 702.28125$ cubic inches. $\times .263 = 184.7$ lbs. nearly.

EXAMPLE 2.—Required the weight of an imperial gallon of proof spirits.

$277.274 \times .03352 = 9.294$ lbs. nearly.

EXAMPLE 3.—Required the thickness of metal for a concave copper ball, 8 inches diameter without, so as to sink to its centre in common water.

$8^3 \times .5236 = 268.0832$ cubic inches in the ball, $\div 2 = 134.0416$ cubic inches to be immersed, or cubic inches of water to be removed, —Then $134.0416 \times .578$ weight of a cubic inch of water $= 77.4760448$ ounces weight of water displaced, or, the weight of the copper ball; which divide by 5.159, the weight of a cubic inch of copper, $= 15.0176$ cubic inches of copper in the ball.

Again, $8^2 \times .7854 \times 4 = 202.0624$ square inches, the superficies of the ball; and $15.0176 \div 202.0624 = .0743$ inches, the required thickness of the copper nearly.

EXAMPLE 4.—Required the weight necessary to counterpoise a float of paving stone proper for a steam-engine boiler, &c., the float being 14 inches diameter and $2\frac{1}{2}$ inches thick.

$14^2 \times .7854 \times 2.5 = 384.846$ cubic inches. Then $384.846 \times .0873 = 33.597$ lbs. the weight of the stone. And, $384.846 \times .03617 = 13.919$ lbs. weight of water displaced; then, $33.597 - 13.919 = 19.678$ lbs. the counterpoise required.

APPENDIX;

CONTAINING

CIRCUMFERENCES, SQUARES, CUBES, AND AREAS OF CIRCLES;

SUPERFICIES AND SOLIDITIES OF SPHERES, &c.

APPENDIX.

TABLE

Containing the circumferences, squares, cubes, and areas of circles, from 1 *to* 100, *advancing by a tenth.*

Diam.	*Circum.*	*Square.*	*Cube.*	*Area.*
1	3.1416	1	1	.7854
.1	3.4557	1.21	1.331	.9503
.2	3.7699	1.44	1.728	1.1309
.3	4.0840	1.69	2.197	1.3273
.4	4.3982	1.96	2.744	1.5393
.5	4.7124	2.25	3.375	1.7671
.6	5.0265	2.56	4.096	2.0106
.7	5.3407	2.89	4.913	2.2698
.8	5.6548	3.24	5.832	2.5446
.9	5.9690	3.61	6.859	2.8352
2	6.2832	4	8	3.1416
.1	6.5973	4.41	9.261	3.4636
.2	6.9115	4.84	10.648	3.8013
.3	7.2256	5.29	12.167	4.1547
.4	7 5398	5.76	13.824	4.5239
.5	7.8540	6.25	15.625	4.9087
.6	8.1681	6.76	17.576	5.3093
.7	8.4823	7.29	19.683	5.7255
.8	8.7964	7.84	21.952	6.1575
.9	9.1106	8.41	24.389	6.6052
3	9.4248	9	27	7.0686
.1	9.7389	9.61	29.791	7.5476
.2	10.0531	10.24	32.768	8.0424
.3	10.3672	10.89	35.937	8.5530
.4	10.6814	11.56	39.304	9.0792
.5	10.9956	12.25	42.875	9.6211
.6	11.3097	12.96	46.656	10.1787
.7	11.6239	13.69	50.653	10.7521
.8	11.9380	14.44	54.872	11.3411
.9	12.2522	15.21	59.319	11.9459
4	12.5664	16	64	12.5664
.1	12.8805	16.81	68.921	13.2025
.2	13.1947	17.64	74.088	13.8544
.3	13.5088	18.49	79.507	14.5220
.4	13.8230	19.36	85.184	15.2053
.5	14.1372	20.25	91.125	15.9043
.6	14.4513	21.16	97.336	16.6190
.7	14.7655	22.09	103.823	17.3494
.8	15.0796	23.04	110.592	18.0956
.9	15.3938	24.01	117.649	18.8574

Diam.	Circum.	Square.	Cube.	Area.
5	15.7080	25	125	19.6350
.1	16.0221	26.01	132.651	20.4282
.2	16.3363	27.04	140.608	21.2372
.3	16.6504	28.09	148.877	22.0618
.4	16.9646	29.16	157.464	22.9022
.5	17.2788	30.25	166.375	23.7583
.6	17.5929	31.36	175.616	24.6301
.7	17.9071	32.49	185.193	25.5176
.8	18.2212	33.64	195.112	26.4208
.9	18.5354	34.81	205.379	27.3397
6	18.8496	36	216	28.2744
.1	19.1637	37.21	226.981	29.2247
.2	19.4779	38.44	238.328	30.1907
.3	19.7920	39.69	250.047	31.1725
.4	20.1062	40.96	262.144	32.1699
.5	20.4204	42.25	274.625	33.1831
.6	20.7345	43.56	287.496	34.2120
.7	21.0487	44.89	300.763	35.2566
.8	21.3628	46.24	314.432	36.3168
.9	21.6770	47.61	328 509	37.3928
7	21.9912	49	343	38.4846
.1	22.3053	50.41	357.911	39.5920
.2	22.6195	51.84	373.248	40.7151
.3	22.9336	53.29	389.017	41.8539
.4	23.2478	54.76	405.224	43.0085
.5	23.5620	56.25	421.875	44.1787
.6	23.8761	57.76	438.976	45.3647
.7	24.1903	59.29	456.533	46.5663
.8	24.5044	60.84	474.552	47.7837
.9	24.8186	62.41	493.039	49.0168
8	25.1328	64	512	50.2656
.1	25.4469	65.61	531.441	51.5300
.2	25.7611	67.24	551.368	52.8102
.3	26.0752	68.89	571.787	54.1062
.4	26.3894	70.56	592.704	55.4178
.5	26.7036	72.25	614.125	56.7451
.6	27.0177	73.96	636.056	58.0881
.7	27.3319	75.69	658.503	59.4469
.8	27.6460	77.44	681.472	60.8213
.9	27.9602	79.21	704.969	62.2115
9	28.2744	81	729	63.6174
.1	28.5885	82.81	753.571	65.0389
.2	28.9027	84.64	778.688	66.4762
.3	29.2168	86.49	804.357	67.9292
.4	29.5310	88.36	830.584	69.3979
.5	29.8452	90.25	857.375	70.8823
.6	30.1593	92.16	884.736	72.3824
.7	30.4735	94.09	912.673	73.8982
.8	30.7876	96.04	941.192	75.4298
.9	31.1018	98.01	970.299	76.9770

Diam.	*Circum.*	*Square.*	*Cube.*	*Area.*
10	31 4160	100	1000	78.5400
.1	31.7301	102.01	1030.301	80.1186
.2	32.0443	104.04	1061.208	81.7130
.3	32.3580	106.09	1092.727	83.3230
.4	32.6726	108.16	1124.864	84.9488
.5	32.9868	110 25	1157.625	86.5903
.6	33.3009	112.36	1191.016	88.2475
.7	33.6151	114.49	1225.043	89.9204
.8	33.9292	116.64	1259.712	91.6090
.9	34.2434	118.81	1295.029	93.3133
11	34.5576	121	1331	95.0334
.1	34.8717	123.21	1367.631	96.7691
.2	35.1859	125.44	1404.928	98.5205
.3	35 5010	127.69	1442.897	100.2877
.4	35.8142	129.96	1481.544	102.0705
.5	36.1284	132.25	1520.875	103.8691
.6	36.4425	134.56	1560.896	105.6834
.7	36.7567	136.89	1601.613	107.5134
.8	37.0708	139.24	1643.032	109.3590
.9	37.3840	141.61	1685.159	111.2204
12	37.6992	144	1728	113.0976
.1	38.0133	146.41	1771.561	114.9904
.2	38.3275	148.84	1815.848	116.8989
.3	38.6416	151.29	1860.867	118.8231
.4	38.9558	153.76	1906.624	120.7631
.5	39.2700	156.25	1953.125	122.7187
.6	39.5841	158.76	2000.376	124.6901
.7	39.8983	161.29	2048.383	126.6771
.8	40.2124	163.84	2097.152	128.6799
.9	40.5266	166.41	2146.689	130.6984
13	40 8408	169	2197	132.7326
.1	41.1549	171.61	2248.091	134.7824
.2	41.4691	174.24	2299.968	136.8480
.3	41.7832	176.89	2352.637	138.9294
.4	42.0974	179.56	2406.104	141.0264
.5	42.4116	182.25	2460.375	143.1391
.6	42.7257	184 96	2515.456	145.2675
.7	43.0399	187.69	2571.353	147.4117
.8	43.3540	190.44	2628.072	149 5715
.9	43.6682	193.21	2685.619	151.7471
14	43.9824	196	2744	153.9384
.1	44.2965	198.81	2803.221	156.1453
.2	44.6107	201.64	2863.288	158.3680
.3	44.9248	204.49	2924.207	160.6064
.4	45.2390	207.36	2985.984	162.8605
.5	45.5532	210.25	3048.625	165.1303
.6	45.8673	213.16	3112.136	167.4158
.7	46.1815	216.09	3176.523	169.7170
.8	46.4956	219 04	3241.792	172.0340
.9	46.8098	222.01	3307.949	174.3666

Diam	Circum.	Square.	Cube.	Area.
15	47.1240	225	3375	176.7150
.1	47.4381	228.01	3442.951	179.0790
.2	47.7523	231.04	3511.808	181.4588
.3	48.0664	234.09	3581.577	183.8542
.4	48.3806	237.16	3652.264	186.2654
.5	48.6948	240.25	3723.875	188.6923
.6	49.0089	243 36	3796.416	191.1349
.7	49.3231	246.49	3869.893	193.5932
.8	49.6372	249.64	3944.312	196.0672
.9	49.9514	252.81	4019.679	198.5569
16	50.2656	256	4096	201.0624
.1	50.5797	259.21	4173.281	203.5835
.2	50.8939	262.44	4251.528	206.1203
.3	51.2080	265.69	4330.747	208.6729
.4	51.5224	268.96	4410.944	211.2411
.5	51.8364	272.25	4492.125	213.8251
.6	52.1505	275.56	4574 296	216.4248
.7	52.4647	278.89	4657.463	219.0402
.8	52.7788	282.24	4741.632	221.6712
.9	53.0930	285.61	4826.809	224.3180
17	53.4072	289	4913	226.9806
.1	53.7213	292.41	5000 211	229.6588
.2	54.0355	295.84	5088.448	232.3527
.3	54.3496	299.29	5177.717	235.0623
.4	54 6038	302.76	5268.024	237.7877
.5	54.9780	306.25	5359.375	240.5287
.6	55.2921	309.76	5451.776	243.2855
.7	55.6063	313.29	5545 233	246.0579
.8	55.9204	316.84	5639.752	248.8461
.9	56.2346	320.41	5735.339	251.6500
18	56.5488	324	5832	254.4696
.1	56 8629	327.61	5929.741	257.3048
.2	57.1771	331.24	6028.568	260.1558
.3	57.4912	334.89	6128.487	263.0226
.4	57.8054	338.56	6229.504	265.9050
.5	58.1196	342.25	6331.625	268.8031
.6	58.4337	345.96	6434.856	271.7169
.7	58.7479	349.69	6539.203	274.6465
.8	59.0620	353.44	6644 672	277.5917
.9	59.3762	357.21	6751.269	280.5527
19	59.6904	361	6859	283.5294
.1	60.0045	364.81	6967.871	286.5217
.2	60.3187	368.64	7077.888	289.5298
.3	60.6328	372.49	7189.057	292.5536
.4	60.9470	376.36	7301.384	295.5931
.5	61.2612	380.25	7414.875	298.6483
.6	61.5753	384.16	7529.536	301.7192
.7	61.8895	388.09	7645.373	304.8060
.8	62.2036	392.04	7762.392	307.9082
.9	62.5178	396.01	7880.599	311.0252

Diam	*Circum.*	*Square.*	*Cube.*	*Area.*
20	62.8320	400	8000	314.1600
.1	63.1461	404.01	8120.601	317.3094
.2	63.4603	408.04	8242.408	320.4746
.3	63.7744	412.09	8365.427	323.6554
.4	64.0886	416.16	8489.664	326.8520
.5	64.4028	420.25	8615.125	330.0643
.6	64.7161	424.36	8741.816	333.2923
.7	65.0311	428.49	8869.743	336.5360
.8	65.3452	432.64	8998.912	339.7954
.9	65.6594	436.81	9129.329	343.0705
21	65.9736	441	9261	346.3614
.1	66.2870	445.21	9393.931	349.6679
.2	66.6012	449.44	9528.128	352.9901
.3	66.7916	453.69	9663.597	356.3281
.4	67.2930	457.96	9800.344	359.6817
.5	67.5444	462.25	9938.375	363.0511
.6	67 8585	466.56	10077.696	366.4362
.7	68.1727	470.89	10218.313	369.8370
.8	68.4368	475.24	10360.232	373.2534
.9	68.8010	479.61	10503.459	376.6856
22	69.1152	484	10648	380.1336
.1	69.4293	488.41	10793.861	383.5972
.2	69.7435	492.84	10941.048	387.0765
.3	70.0576	497.29	11089.567	390.5751
.4	70.3718	501.76	11239.424	394.0823
.5	70.6860	506.25	11390.625	397.6087
.6	71.0001	510.76	11543.176	401.1509
.7	71.3143	515.29	11697.083	404.7087
.8	71.6284	519.84	11852.352	408.2823
.9	71.9426	524.41	12008.989	411.8716
23	72.2568	529	12167	415.4766
.1	72.5709	533.61	12326.391	419.0972
.2	72 8851	538.24	12487.168	422.7336
.3	73.1992	542.89	12649.337	426.3858
.4	73.5134	547.56	12812.904	430.0536
.5	73.8276	552.25	12977.875	433.7371
.6	74.1417	556.96	13144.256	437.4363
.7	74.4559	561.69	13312.053	441.1511
.8	74.7680	566.44	13481.272	444.8819
.9	75.0882	571.21	13651.919	448.6283
24	75.3984	576	13824	452.3904
.1	75.7125	580.81	13997.521	456.1681
.2	76.0267	585.64	14172.488	459.9616
.3	76.3408	590.49	14348 907	463.7708
.4	76.6528	595.36	14526.784	467.5957
.5	76.9692	600.25	14706.125	471.4363
.6	77.2833	605.16	14886.936	475.2926
.7	77.5975	610.09	15069.223	479.1646
.8	77.9116	615.04	15252.992	483.0524
.9	78.2258	620.01	15438.249	486.9558

Diam.	Circum.	Square.	Cube.	Area.
25	78.5400	625	15625	490.8750
.1	78.8541	630.01	15813.251	494.8098
.2	79.1683	635.04	16003.008	498 7604
.3	79.4824	640.09	16194 277	502.7266
.4	79.7966	645.16	16387.064	506.7086
.5	80.8108	650.25	16581.375	510.7063
.6	80.4249	655.36	16777.216	514.7196
.7	80.7391	660.49	16974.593	518.7488
.8	81.0532	665.64	17173.512	522.7936
.9	81.3674	670.81	17373.979	526.8541
26	81.6816	676	17576	530.9304
.1	81.9976	681.21	17779.581	535.0223
.2	82.3099	686.44	17984.728	539.1299
.3	82.6240	691.69	18191.447	543.2533
.4	82.9382	696.96	18399.744	547.3923
.5	83.2524	702.25	18609.625	551.5471
.6	83.5665	707 56	18821.096	555.7176
.7	83.8807	712.89	19034.163	559.9038
.8	84.1948	718 24	19248.832	564.1056
.9	84 5090	723 61	19465.109	568.3232
27	84.8232	729	19683	572.5566
.1	85.1373	734 41	19902.511	576.8056
.2	85.4515	739.84	20123.648	581.0703
.3	85 7656	745.29	20346.417	585 3507
.4	86.0798	750.76	20570.824	589.6469
.5	86.3940	756.25	20796 875	593.9587
.6	86.7081	761.76	21024.576	598.2863
.7	87.0223	767.29	21253.933	602.6295
.8	87.3364	772.84	21484.952	606.9885
.9	87.6506	778 41	21717.639	611.3632
28	87.9648	784	21952	615.7536
.1	88.2789	789.61	22188.041	620.1596
.2	88.5931	795.24	22425.768	624.5814
.3	88.9072	800.89	22665.187	629.0190
.4	89.2214	806.56	22906.304	633.4722
.5	89.5356	812.25	23149.125	637.9411
.6	89.8497	817.96	23393.656	642.4257
.7	90.1639	823.69	23639.903	646.9261
.8	90.4780	829.44	23887.872	651.4421
.9	90.7922	835.21	24137.569	655.9739
29	91.1064	841	24389	660.5214
.1	91.4205	846.81	24642.171	665.0845
.2	91.7347	852 64	24897.088	669.6634
.3	92.0488	858.49	25153.757	674.2580
.4	92.3630	864.36	25412.184	678.8683
.5	92.6772	870.25	25672.375	683 4943
.6	92.9913	876.16	25934.336	688.1360
.7	93.3055	882.09	26198.073	692.7934
.8	93.6196	888.04	26463.592	697.4666
.9	93.9338	894.01	26730.899	702.1554

Diam.	*Circum.*	*Square.*	*Cube.*	*Area.*
30	94.2480	900	27000	706.8600
.1	94.5621	906.01	27270.901	711.5802
.2	94.8763	912.04	27543.608	716.3162
.3	95.1904	918.09	27818.127	721.0678
.4	95.5046	924.16	28094.464	725.8352
.5	95.8188	930.25	28372.625	730.6183
.6	96.1329	936.36	28652.616	735.4171
.7	96.4471	942.49	28934.443	740.2316
.8	96.7612	948.64	29218.112	745.0618
.9	97.0754	954.81	29503.629	749.9077
31	97.3896	961	29791	754.7694
.1	97.7037	967.21	30080.231	759.6467
.2	98.0179	973.44	30371.328	764.5397
.3	98.3320	979.69	30664.297	769.4485
.4	98.6452	985.96	30959.144	774.3729
.5	98.9604	992.25	31255.875	779.3131
.6	99.2745	998.56	31554.496	784.2689
.7	99.5887	1004.89	31855.013	789.2406
.8	99.9028	1011.24	32157.432	794.2278
.9	100.2170	1017.61	32461.759	799.2308
32	100.5312	1024	32768	804.2496
.1	100.8453	1030.41	33076.161	809.2840
.2	101.1595	1036.84	33386.248	814.3341
.3	101.4736	1043.29	33698.267	819.3999
.4	101.7478	1049.76	34012.224	824.4815
.5	102.1020	1056.25	34328.125	829.5787
.6	102.4161	1062.76	34645.976	834.6917
.7	102.7303	1069.29	34965.783	839.8203
.8	103.0444	1075.84	35287.552	844.9647
.9	103.3586	1082.41	35611.289	850.1248
33	103.6728	1089	35937	855.3006
.1	103.9869	1095.61	36264.691	860.4920
.2	104.3011	1102.24	36594.368	865.6992
.3	104.6151	1108.89	36926.037	870.9222
.4	104.9294	1115.56	37259.704	876.1608
.5	105.2436	1122.25	37595.375	881.4151
.6	105.5577	1128.96	37933.056	886.6851
.7	105.8719	1135.69	38272.753	891.9709
.8	106.1860	1142.44	38614.472	897.2723
.9	106.5002	1149.21	38958.219	902.5895
34	106.8144	1156	39304	907.9224
.1	107.1285	1162.81	39651.821	913.2709
.2	107.4272	1169.64	40001.688	918.6352
.3	107.7568	1176.49	40353.607	924.0115
.4	108.0710	1183.36	40707.584	929.4109
.5	108.3852	1190.25	41063.625	934.8223
.6	108.6993	1197.16	41421.736	940.2494
.7	109.0352	1204.09	41781.923	945.6922
.8	109.3076	1211.04	42144.192	951.1508
.9	109.6418	1218.01	42508.549	956.8250

Diam.	Circum.	Square.	Cube.	Area.
35	109.9560	1225	42875	962.1150
.1	110.2701	1232.01	43243.551	967.6206
.2	110.5843	1239.04	43614.208	973.1420
.3	110.8984	1246.09	43986.977	978.6790
.4	111.2126	1253.16	44361.864	984.2318
.5	111.5268	1260.25	44738.875	989.8003
.6	111.8409	1267.36	45118.016	995.3845
.7	112.1551	1274.49	45499.293	1000.9843
.8	112.4692	1281.64	45882.712	1006.6000
.9	112.7834	1288.81	46268.279	1012.2313
36	113.0976	1296	46656	1017.8784
.1	113.4117	1303.21	47045.831	1023.5411
.2	113.7259	1310.44	47437.928	1029.2195
.3	114.0400	1317.69	47832.147	1034.9131
.4	114.3542	1324.96	48228.544	1040.6235
.5	114.6684	1332.25	48627.125	1046.3491
.6	114.9825	1339.56	49027.896	1052.0904
.7	115.2967	1346.89	49430.863	1057.8474
.8	115.6108	1354.24	49836.032	1063.6200
.9	115.9250	1361.61	50243.409	1069.4084
37	116.2392	1369	50653	1075.2126
.1	116.5533	1376.41	51064.811	1081.0324
.2	116.8675	1383.84	51478.848	1086.8679
.3	117.1816	1391.29	51895.117	1092.7191
.4	117.4958	1398.76	52313.624	1098.5862
.5	117.8100	1406.25	52734.375	1104.4687
.6	118.1241	1413.76	53157.376	1110.3671
.7	118.4383	1421.29	53582.633	1116.2811
.8	118.7524	1428.84	54010.152	1122.2109
.9	119.0666	1436.41	54439.939	1128.1564
38	119.3808	1444	54872	1134.1176
.1	119.6949	1451.61	55306.341	1140.0946
.2	120.0091	1459.24	55742.968	1146.0870
.3	120.3232	1466.89	56181.887	1152.0954
.4	120.6374	1474.56	56623.104	1158.1194
.5	120.9516	1482.25	57066.625	1164.1591
.6	121.2657	1489.96	57512.456	1170.2145
.7	121.5799	1497.69	57960.603	1176.2857
.8	121.8940	1505.44	58411.072	1182.3725
.9	122.2082	1513.21	58863.869	1188.4651
39	122.5224	1521	59319	1294.5394
.1	122.8365	1528.81	59776.471	1200.7273
.2	123.1507	1536.64	60236.288	1206.8770
.3	123.4648	1544.49	60698.457	1213.0424
.4	123.7790	1552.36	61162.984	1219.2243
.5	124.0932	1560.25	61629.875	1225.4203
.6	124.4073	1568.16	62099.136	1231.6328
.7	124.7215	1576.09	62570.773	1237.8610
.8	125.0356	1584.04	63044.792	1244.1210
.9	125.3498	1592.01	63521.199	1250.3646

Diam.	Circum.	Square.	Cube.	Area.
40	125.6640	1600	64000	1256.6400
.1	125.9781	1608.01	64481.201	1262.9310
.2	126.2923	1616.04	64964.808	1269.2388
.3	126.6064	1624.09	65450.827	1275.5602
.4	126.9206	1632.16	65939 264	1281.8984
.5	127.2348	1640.25	66430 125	1288.2523
.6	127.5489	1648.36	66923.416	1294.6219
.7	127.8631	1656 49	67419.143	1301.0071
.8	128.1772	1664.64	67917.312	1307.4082
.9	128.4914	1672.81	68417.929	1313.8249
41	128.8056	1681	68921	1320.2574
.1	129.1197	1689.21	69426.531	1326.7055
.2	129.4323	1697.44	69934.528	1333.1693
.3	129.7480	1705.69	70444.997	1339.6489
.4	130.0622	1713.96	70957.944	1346.1441
.5	130.3764	1722.25	71473.375	1352.6551
.6	130.6905	1730.56	71991.296	1359.1818
.7	131.0047	1738.89	72511.713	1365.7242
.8	131.3188	1747.24	73034.632	1372.2822
.9	131.6320	1755.61	73560.059	1378.8560
42	131.9472	1764	74088	1385.4456
.1	132.2613	1772.41	74618.461	1392.0508
.2	132.5755	1780.84	75151.448	1398.6717
.3	132.8896	1789.29	75686.967	1405.3083
.4	133.2038	1797.76	76225.024	1411.9607
.5	133.5180	1806.25	76765.625	1418.6287
.6	133.8321	1814.76	77308.776	1425.3125
.7	134.1463	1823.29	77854.483	1432.0119
.8	134.4604	1831.84	78402.752	1438.7271
.9	134.7746	1840.41	78958.589	1445.4580
43	135.0888	1849	79507	1452.2046
.1	135.4029	1857.61	80062.991	1458.9668
.2	135.7171	1866.24	80621.568	1465.7448
.3	136.0332	1874.89	81182.737	1472.5385
.4	136.3454	1883.56	81746.504	1479.3480
.5	136.6596	1892.25	82312 875	1486.1731
.6	136.9737	1900.96	82881.856	1493.0139
.7	137.2879	1909.69	83453.453	1499.8705
.8	137.6020	1918.44	84027.672	1506.7427
.9	137.9162	1927.21	84604.519	1513.6287
44	138 2304	1936	85184	1520.5344
.1	138 5445	1944.81	85766.121	1527.4537
.2	138.8587	1953.64	86350.888	1534.3888
.3	139.1728	1962.49	86938 307	1541.3396
.4	139.4870	1971.36	87528.384	1548.3061
.5	139.8012	1980.25	88121.125	1555.2883
.6	140.1153	1989.16	88716.536	1562.2862
.7	140.4295	1998.09	89314.623	1569.2998
.8	140.7436	2007.04	89915.392	1576.3292
.9	141.0578	2016.01	90518.849	1583.3742

Diam.	Circum.	Square.	Cube.	Area.
45	141.3720	2025	91125	1590.4350
.1	141.6861	2034.01	91733.851	1597.5114
.2	142.0003	2043.04	92345.408	1604.6036
.3	142.3144	2052.09	92959.677	1611.7114
.4	142.6286	2061.16	93576.664	1618.8350
.5	142.9428	2070.25	94196.375	1625.9743
.6	143.2569	2079.36	94818.816	1633.1293
.7	143.5711	2088.49	95443.993	1640.3020
.8	143.8852	2097.64	96071.912	1647.4864
.9	144.1994	2106.81	96702.579	1654.6885
46	144 5136	2116	97336	1661.9064
.1	144.8277	2125.21	97972.181	1669.1399
.2	145.1419	2134.44	98611.128	1676.3891
.3	145.4560	2143.69	99252.847	1683.6541
.4	145.7702	2152.96	99897.344	1690.9347
.5	146.0844	2162.25	100544.625	1698.2311
.6	146.3985	2171.56	101194.696	1705.5432
.7	146.7127	2180.89	101847.563	1712.8710
.8	147.0268	2190.24	102503.232	1720.2144
.9	147.3410	2199.61	103161.709	1727.5736
47	147.6552	2209	103823	1734.9486
.1	147.9693	2218.41	104487.111	1742.3392
.2	148.2835	2227.84	105154.048	1749.7455
.3	148.5976	2237.29	105823.817	1757.1675
.4	148.9118	2246.76	106496.424	1764.6045
.5	149.2260	2256.25	107171.875	1772.0587
.6	149.5361	2265.76	107850.176	1779.5279
.7	149.8543	2275.29	108531.333	1787.0127
.8	150.1684	2284.84	109215.352	1794.5133
.9	150.4826	2294.41	109902.239	1802.0296
48	150.7968	2304	110592	1809.5616
.1	151.1109	2313.61	111284.641	1817.1092
.2	151.4251	2323.24	111980.168	1824.6726
.3	151.7392	2332.89	112678.587	1832.2518
.4	152.0534	2342.56	113379.904	1839.8466
.5	152.3676	2352.25	114084.125	1847.4571
.6	152.6817	2361.96	114791.256	1855.0833
.7	152.9959	2371.69	115501.303	1862.7253
.8	153.3100	2381.44	116214.272	1870.3829
.9	153.6242	2391.21	116930.169	1878.0563
49	153.9384	2401	117649	1885.7454
.1	154.2525	2410.81	118370.771	1893.4501
.2	154.5667	2420.64	119095.488	1901.1706
.3	154.8808	2430.49	119823.157	1908.9068
.4	155.1950	2440.36	120553.784	1916.6587
.5	155.5092	2450.25	121287.375	1924.4263
.6	155.8233	2460.16	122023.936	1932.2096
.7	156.1375	2470.09	122763.473	1940.0086
.8	156.4516	2480.04	123505.992	1947.8234
.9	156.7558	2490.01	124251.499	1955.6538

Diam.	*Circum.*	*Square.*	*Cube.*	*Area.*
50	157.0800	2500	125000	1963.5000
.1	157.3941	2510.01	125751.501	1971.3618
.2	157.7083	2520.04	126506.008	1979.2394
.3	158.0224	2530.09	127263 527	1987.1326
.4	158.3366	2540.16	128024.064	1995.0416
.5	158 6508	2550.25	128787.625	2002.9663
.6	158.9649	2560.36	129554.216	2010.9067
.7	159.2791	2570.49	130323 843	2018.8628
.8	159.5932	2580.64	131096.512	2026.8346
.9	159.9074	2590.81	131872.229	2034.8770
51	160.2216	2601	132651	2042.8254
.1	160.5357	2611.21	133432.831	2050.8443
.2	160 8499	2621.44	134217.728	2058.8784
.3	161.1640	2631.69	135005.697	2066.9293
.4	161.4782	2641.96	135796.744	2074.9953
.5	161.7924	2652.25	136590.875	2083.0771
.6	162.1065	2662.56	137388.096	2091.1746
.7	162.4207	2672.89	138188.413	2099.2878
.8	162.7348	2683.24	138991.832	2107.4166
.9	163.0490	2693 61	139798.359	2115.5612
52	163.3632	2704	140608	2123.7216
.1	163.6773	2714.41	141420.761	2131.8976
.2	163.9935	2724.84	142236.648	2140.0893
.3	164.3056	2735.29	143055.667	2148.2967
.4	164.6198	2745.76	143877.824	2156.5199
.5	164.9340	2756.25	144703.125	2164.7587
.6	165.2481	2766.76	145531.576	2173.0133
.7	165.5623	2777.29	146363.183	2181.2835
.8	165.8764	2787.84	147197.952	2189.5695
.9	166.1906	2798.41	148035.889	2197.8712
53	166.5048	2809	148877	2206.1886
.1	166.8189	2819.61	149721.291	2214.5216
.2	167.1331	2830.24	150568.768	2222.8704
.3	167.4472	2840.89	151419 437	2231.2350
.4	167.7614	2851.56	152273.304	2239.6152
.5	168.0756	2862.25	153130.375	2248.0111
.6	168 3897	2872.96	153990.656	2256.4227
.7	168.7049	2883.69	154854.153	2264 8701
.8	169.0180	2894.44	155720.872	2273.2931
.9	169.3322	2905.21	156590.819	2281.7519
54	169.6464	2916	157464	2290.2264
.1	169.9605	2926.81	158340.421	2298.7165
.2	170.2747	2937.64	159220.088	2307.2224
.3	170.5888	2948.49	160103 007	2315.7440
.4	170.9030	2959.36	160989.184	2324 2813
.5	171.2172	2970.25	161878.625	2332.8343
.6	171.5313	2981.16	162771.336	2341.4030
.7	171.8455	2992.09	163667.323	2349.9874
.8	172.1596	3003 04	164566.592	2358.5876
.9	172.4738	3014.01	165469.149	2367.2034

Diam.	Circum.	Square.	Cube.	Area.
55	172.7880	3025	166375	2375.8350
.1	173.1021	3036.01	167284.151	2384.4822
.2	173.4163	3047.04	168196.608	2393.1452
.3	173.7304	3058.09	169112.377	2401.8238
.4	174.0446	3069.16	170031.464	2410.5182
.5	174.3588	3080.25	170953.875	2419.2283
.6	174.6729	3091.36	171879.616	2427.9541
.7	174.9771	3102.49	172808.693	2436.6956
.8	175.3092	3113.64	173741.112	2445.4528
.9	175.6154	3124.81	174676.879	2454.2257
56	175.9296	3136	175616	2463.0144
.1	176.2437	3147.21	176558.481	2471.8187
.2	176.5579	3158.44	177504.328	2480.6387
.3	176.8720	3169.69	178453.547	2489.4745
.4	177.1862	3180.96	179406.144	2498.3259
.5	177.5004	3192.25	180362.125	2507.1931
.6	177.8145	3203.56	181321.496	2516.0760
.7	178.1287	3214.89	182284.263	2524.9736
.8	178.4428	3226.24	183250.432	2533.8888
.9	178.7570	3237.61	184220.009	2542.8188
57	179.0712	3249	185193	2551.7646
.1	179.3853	3260.41	186169.411	2560.7260
.2	179.6995	3271.84	187149.248	2569.7031
.3	180.0136	3283.29	188132.517	2578.6959
.4	180.3278	3294.76	189119.224	2587.7045
.5	180.6420	3306.25	190109.375	2596.7287
.6	180.9561	3317.76	191102.976	2605.7687
.7	181.2803	3329.29	192100.033	2614.8243
.8	181.5844	3340.84	193100.552	2623.8957
.9	181.8986	3352.41	194104.539	2632.9828
58	182.2128	3364	195112	2642.0856
.1	182.5269	3375.61	196122.941	2651.2046
.2	182.8411	3387.24	197137.368	2660.3382
.3	183.1552	3398.89	198155.287	2669.4882
.4	183.4694	3410.56	199176.704	2678.6538
.5	183.7836	3422.25	200201.625	2687.8351
.6	184.0977	3433.96	201230.056	2697.0321
.7	184.4119	3445.69	202262.003	2706.2449
.8	184.7260	3457.44	203297.472	2715.4733
.9	185.0402	3469.21	204336.469	2724.7175
59	185.3544	3481	205379	2733.9774
.1	185.6685	3492.81	206425.071	2743.2529
.2	185.9827	3504.64	207474.688	2752.5442
.3	186.2696	3516.49	208527.857	2761.8512
.4	186.6110	3528.36	209584.584	2771.1739
.5	186.9252	3540.25	210644.875	2780.5123
.6	187.2393	3552.16	211708.736	2789.8664
.7	187.5535	3564.09	212776.173	2799.2362
.8	187.8676	3576.04	213847.192	2808.6218
.9	188.1818	3588.01	214921.799	2818.0230

Diam.	*Circum.*	*Square.*	*Cube.*	*Area.*
60	188.4960	3600	216000	2827.4400
.1	188.8101	3612.01	217081.801	2836.8726
.2	189.1243	3624.04	218167.208	2846.3210
.3	189.4384	3636.09	219256.227	2855.7850
.4	189.7526	3648 16	220348.864	2865.2648
.5	190.0668	3660.25	221445.125	2874.7603
.6	190.3809	3672.36	222545.016	2884.2615
.7	190.6951	3684.49	223648.543	2893.7984
.8	191.0092	3696.64	224755.712	2903.3410
.9	191.3234	3708.81	225866.529	2912.8993
61	191.6376	3721	226981	2922.4734
.1	191.9517	3733.21	228099.131	2932.0631
.2	192.2659	3745.44	229220.928	2941.6685
.3	192.5800	3757.69	230346.397	2951.2897
.4	192.8942	3769.96	231475.544	2960 9265
.5	193.2084	3782.25	232608.375	2970.5791
.6	193.5225	3794.56	233744.896	2980.2474
.7	193.8367	3806.89	234885.113	2989.9314
.8	194.1508	3819 24	236029.032	2999.6300
.9	194.4650	3831.61	237176.659	3009.3464
62	194.7792	3844	238328	3019.0776
.1	195.0933	3856.41	239483 061	3028 8244
.2	195.4075	3868.84	240641.848	3038.5869
.3	195.7216	3881.29	241804.367	3048.3651
.4	196.0358	3893 76	242970.624	3058.1591
.5	196.3500	3906.25	244140.625	3067.9687
.6	196.6641	3918.76	245314.376	3077 7941
.7	196.9783	3931.29	246491.883	3087.6341
.8	197.2924	3943.84	247673.152	3097.4919
.9	197.6066	3956.41	248858.189	3107.3644
63	197.9208	3969	250047	3117.2526
.1	198.2349	3981.61	251239 591	3127.1564
.2	198.5491	3994.24	252435.968	3137.0758
.3	198.8632	4006.89	253636.137	3147.0114
.4	199.1774	4019.56	254840.104	3156.9664
.5	199.4916	4032.25	256047.875	3166.9291
.6	199.8057	4044.96	257259.456	3176.9115
.7	200.1199	4057.69	258474.853	3186.9097
.8	200.4340	4070.44	259694.072	3196 9235
.9	200.7482	4083.21	260917.119	3206.9531
64	201.0624	4096	262144	3216.9984
.1	201.3765	4108,81	263374.721	3227.0593
.2	201.6907	4121.64	264609.288	3237.1360
.3	202.0048	4134 49	265847.707	3247.2284
.4	202.3190	4147.36	267089.984	3257.3365
.5	202.6332	4160.25	268336.125	3267.4603
.6	202.9473	4173.16	269586.136	3277.5998
.7	203 2615	4186,09	270840 023	3287.7550
.8	203.5756	4199.04	272097.792	3297.9260
.9	203.8898	4212.01	273359·449	3308.1126

Diam.	Circum.	Square.	Cube.	Area.
65	204.2040	4225	274625	3318.3150
.1	204.5181	4238.01	275894 451	3328.5340
.2	204.8323	4251.04	277167.808	3338 7668
.3	205.1464	4264.09	278445.077	3349.0162
.4	205.4606	4277.16	279726.264	3359.2814
.5	205.7748	4290.25	281011.375	3369.5623
.6	206.0889	4303.36	282300.416	3379.8589
.7	206.4031	4316.49	283593 393	3390.1712
.8	206.7172	4329 64	284890.312	3400.4992
.9	207.0314	4342.81	286191.179	3410.8429
66	207.3456	4356	287496	3421.2024
.1	207.6597	4369.21	288804.781	3431.5775
.2	207.9739	4382.44	290117.528	3441.9633
.3	208.2880	4395.69	291434.247	3452.3749
.4	208.6022	4408.96	292754.944	3462.7971
.5	208.9164	4422.25	294079.625	3473.2351
.6	209.2305	4435.56	295408.296	3483.6888
.7	209.5447	4448.89	296740.963	3494.1640
.8	209.8588	4462.24	298077.632	3504.6432
.9	210.1730	4475.61	299418.309	3515.1430
67	210.4872	4489	300763	3525.6606
.1	210.8013	4502.41	302111.711	3536.1928
.2	211.1155	4515.84	303464.448	3546.7407
.3	211.4296	4529.29	304821.217	3557.3043
.4	211.7438	4542.76	306182.024	3567.8837
.5	212.0580	4556.25	307546.875	3578.4787
.6	212.3721	4569.76	308915.776	3589.0895
.7	212.6863	4583.29	310288.733	3599.7159
.8	213.0004	4596.84	311665.752	3610.3581
.9	213.3146	4610.41	313046.839	3621.0160
68	213.6288	4624	314432	3631.6896
.1	213.9429	4637.61	315821.241	3642.3788
.2	214.2571	4651.24	317214.568	3653.0838
.3	214.5712	4664.89	318611.987	3663.8040
.4	214.8854	4678.56	320013.504	3674.5410
.5	215.1996	4692.25	321419.125	3685.2931
.6	215.5137	4705.96	322828.856	3696.0060
.7	215.8279	4719.69	324242.703	3706.8445
.8	216.1420	4733.44	325660.672	3717.6437
.9	216.4562	4747.21	327082.769	3728.4587
69	216.7704	4761	328509	3739.2894
.1	217.0845	4774.81	329939.371	3750.1357
.2	217.3987	4788.64	331373.888	3760.9978
.3	217.7128	4802.49	332812.557	3771.8756
.4	218.0270	4816.36	334255.384	3782.7691
.5	218.3412	4830.25	335702.375	3793.6783
.6	218.6553	4844.16	337153.536	3804.6032
.7	218.9695	4858.09	338608.873	3815.5438
.8	219.2836	4872.04	340068.392	3826.5002
.9	219.5978	4886.01	341532.099	3837.4722

Diam.	*Circum.*	*Square.*	*Cube.*	*Area.*
70	219.9120	4900	343000	3848.4600
.1	220.2261	4914.01	344472.101	3859.4952
.2	220.5403	4928.04	345948.408	3870.4826
.3	220.8544	4942.09	347428.927	3881.5174
.4	221.1686	4956 16	348913.664	3892.5680
.5	221.4828	4970.25	350402.625	3903.6343
.6	221.7969	4984.36	351895.816	3914.7163
.7	222.1111	4998.49	353393.243	3925.8140
.8	222.4252	5012.64	354894.912	3936.9274
.9	222.7394	5026.81	356400.829	3948.0565
71	223.0536	5041	357911	3959.2014
.1	223.3677	5055 21	359425.431	3970.3619
.2	223.6819	5069.44	360944.128	3981.5381
.3	223 9960	5083.69	362467.097	3992.7301
.4	224.3102	5097.96	363994.344	4003.9373
.5	224.6244	5112.25	365525.875	4015.1611
.6	224.9385	5126.56	367061.696	4026.4002
.7	225.2527	5140.89	368601.813	4037.6550
.8	225.5668	5155.24	370146.232	4048.9254
.9	225 8810	5169.61	371694.959	4060.2116
72	226.1952	5184	373248	4071.5136
.1	226.5093	5198 41	374805.361	4082.8332
.2	226.8235	5212.84	376367.048	4094.1645
.3	227.1376	5227.29	377933.067	4105.5125
.4	227.4518	5241 76	379503.424	4116.8793
.5	227.7660	5256.25	381078.125	4128.2587
.6	228.0801	5270.76	382657.176	4139.6524
.7	228.3943	5285.29	384240.583	4151.0667
.8	228.7084	5299.84	385828.352	4162·4943
.9	229.0226	5314 41	387420.489	4173.9376
73	229.3368	5329	389017	4185.3966
.1	229.6509	5343.61	390617.891	4196.8712
.2	229.9651	5358.24	392223.168	4208.3614
.3	230.2792	5372.89	393832.837	4219.8678
.4	230.5934	5387.56	395446.904	4231.3896
.5	230 9076	5402.25	397065.375	4242.9271
.6	231.2217	5416.96	398688.256	4254.4803
.7	231.5359	5431.69	400315.553	4266.0493
.8	231.8500	5446.44	401947.272	4277.6339
.9	232.1642	5461.21	403583.419	4289.2343
74	232.4784	5476	405224	4300.8504
.1	232.7925	5490 81	406869.021	4312.4821
.2	233.1067	5505.64	408518.488	4324.1296
.3	233.4208	5520.49	410172 407	4335.7928
.4	233.7350	5535.36	411830.784	4347.4717
.5	234.0492	5550.25	413493 625	4359.1663
.6	234.3633	5565.16	415160.936	4370.8766
.7	234.6775	5580.09	416832.723	4382.6026
.8	234.9916	5595.04	418508.992	4394.3448
.9	235.3058	5610.01	420189.749	4406.1018

Diam.	Circum.	Square.	Cube.	Area.
75	235.6200	5625	421875	4417.8750
.1	235.9341	5640.01	423564.751	4429.6638
.2	236.2483	5655.04	425259.008	4441.4684
.3	236.5624	5670.09	426957.777	4453.2886
.4	236.8766	5685.16	428661.064	4465.1246
.5	237.1908	5700.25	430368.875	4476.9763
.6	237.5049	5715.36	432081.216	4488.8437
.7	237.8191	5730.49	433798.093	4500.7268
.8	238.1332	5745.64	435519.512	4512.6256
.9	238.4474	5760.81	437245.479	4524 5401
76	238.7616	5776	438976	4536.4704
.1	239.0757	5791.21	440711.081	4548.4163
.2	239.3899	5806.44	442450.728	4560.3787
.3	239.7040	5821.69	444194.947	4572.3553
.4	240.0182	5836.96	445943.744	4584.3583
.5	240.3324	5852.25	447697.125	4596 3571
.6	240.6465	5867.56	449455.096	4608.3816
.7	240.9607	5882.89	451217.663	4620.4218
.8	241.2748	5898 24	452984.832	4632.4776
.9	241.5987	5913.61	454756.609	5644.5492
77	241.9032	5929	456533	4656.6366
.1	242.2173	5944.41	458314.011	4668.7396
.2	242.5315	5959.84	460099.648	4680.8583
.3	242.8456	5975.29	461889.917	4692.9927
.4	243.1598	5990.76	463684.824	4705.1429
.5	243.4740	6006.25	465484.375	4717.3087
.6	243.7881	6021.76	467288.576	4729.4903
.7	244.1023	6037.29	469097.433	4741.6875
.8	244.4164	6052.84	470910.952	4753 9605
.9	244.7306	6068.41	472729.139	4766.1292
78	245.0448	6084	474552	4778.3736
.1	245.3589	6099.61	476379.541	4790.6336
.2	245.6731	6115.24	478211.768	4802.9094
.3	245.9872	6130.89	480048.687	4815.2010
.4	246.3014	6146.56	481890.304	4827.5082
.5	246.6156	6162.25	483736.625	4839.8311
.6	246.9297	6177.96	485587.656	4852.1697
.7	247.2439	6193 69	487443.403	4864.5241
.8	247.5480	6209.44	489303.872	4876.8973
.9	247.8722	6225.21	491169.069	4889.2799
79	248.1864	6241	493039	4901.6814
.1	248.5005	6256.81	494913.671	4914.0985
.2	248.8147	6272.64	496793.088	4926.5314
.3	249.1288	6288.49	498677.257	4938.9820
.4	249.4430	6304.36	500566.184	4951.4443
.5	249.7572	6320.25	502459.875	4963.9243
.6	250.0713	6336.16	504358.336	4976.4840
.7	250.3855	6352.09	506261.573	4988.9314
.8	250.6996	6368.04	508169.592	5001.4586
.9	251.0138	6384.01	510082.399	5014.0014

Diam.	Circum.	Square.	Cube.	Area.
80	251.3280	6400	512000	5026.5600
.1	251.6421	6416.01	513922.401	5039.1342
.2	251.9563	6432.04	515849 608	5051.7242
.3	252.2704	6448 09	517781.627	5064.3298
.4	252.5846	6464.16	519718.464	5076.9552
.5	252.8988	6480.25	521660.125	5089.5883
.6	253.2129	6496.36	523606.616	5102.2411
.7	253.5271	6512.49	525557.943	5114.9096
.8	253.8412	6528.64	527514 112	5127.5938
.9	254 1554	6544.81	529475.129	5140.2937
81	254.4696	6561	531441	5153.0094
.1	254.7837	6577.21	533411.731	5165.7407
.2	255.0979	6593.44	535387.328	5178.4877
.3	255.4120	6609.69	537367.797	5191.2505
.4	255.7262	6625.96	539353.144	5204.0285
.5	256.0404	6642.25	541343.375	5216.8231
.6	256.3545	6658.56	543338.496	5229.6330
.7	256.6687	6674.89	545338.513	5242.4586
.8	256.9828	6691.24	547343.432	5255.2998
.9	257.2970	6707.61	549353.259	5268.1568
82	257.6112	6724	551368	5281.0296
.1	257.9253	6740.41	553387.661	5293.9180
.2	258.2395	6756.84	555412.248	5306.8221
.3	258.5536	6773.29	557441.767	5319.7439
.4	258.8646	6789.76	559476.224	5332.6775
.5	259.1820	6806.25	561515.625	5345.6287
.6	259.4961	6822.76	563559.976	5358.5957
.7	259.8103	6839.29	565609.283	5371.5983
.8	260.1244	6855.84	567663.552	5384.5762
.9	260.4386	6872.41	569722.789	5397.5908
83	260.7528	6889	571787	5410.6206
.1	261.0669	6905.61	573856.191	5423.6660
.2	261.3811	6922.24	575930.368	5436.7272
.3	261.6952	6938.89	578009.537	5449.8042
.4	262.0094	6955.56	580093.704	5462.8968
.5	262.3236	6972.25	582182.875	5476.0051
.6	262.6376	6988.96	584277.056	5489.1291
.7	262.9519	7005.69	586376.253	5502.2689
.8	563.2640	7022.44	588480.472	5515.4243
.9	263.5802	7039.21	590589.719	5528 5958
84	263.8944	7056	592704	5541.7824
.1	264.2085	7072.81	594823.321	5554.9849
.2	264.5227	7089.64	596947.688	5568.2032
.3	264.8368	7106.49	599077.107	5581.4372
.4	265.1510	7123.36	601211.584	5594.6869
.5	265.4652	7140.25	603351.125	5607.9523
.6	265.7793	7157.16	605495.736	5621.2334
.7	266.0935	7174.09	607645.423	5634.5682
.8	266.4076	7191.04	609800.192	5647.8428
.9	266.7218	7208.01	611960.049	5661.1710

Diam.	Circum.	Square.	Cube.	Area.
85	267.0360	7225	614125	5674.5150
.1	267.3501	7242.01	616295.051	5687.8746
.2	267.6643	7259.04	618470.208	5701.2500
.3	267.9784	7276.09	620650.477	5714.6410
.4	268.2926	7293.16	622835.864	5728.0478
.5	268.6068	7310.25	625026.375	5741.4703
.6	268.9209	7327.36	627222.016	5754.9085
.7	269.2351	7344.49	629422.793	5768.3624
.8	269.5492	7361.64	631628.712	5781.8320
.9	269.8634	7378.81	633839.779	5795.3173
86	270.1776	7396	636056	5808.8184
.1	270.4917	7413.21	638277.381	5822.3351
.2	270.8059	7430.44	640503.928	5835.8675
.3	271.1200	7447.69	642735.647	5849.4157
.4	271.4342	7464.96	644972.544	5862.9795
.5	271.7484	7482.25	647214.625	5876.5591
.6	272 0665	7499.56	649461.896	5890.1541
.7	272.3767	7516.89	651714.363	5903.7654
.8	272.6908	7534.24	653972.032	5917.3920
.9	273.0050	7551.61	656234.909	5931.0344
87	273.3192	7569	658503	5944.6926
.1	273.6333	7586.41	660776.311	5958.3644
.2	273.9475	7603.84	663054.848	5972.0559
.3	274 2616	7621.29	665338.617	5985.7691
.4	274.5758	7638.76	667627.624	5999.4821
.5	274.8900	7656.25	669921.875	6013.2187
.6	275.2041	7673.76	672221.376	6026.9711
.7	275.5183	7691.29	674526.133	6040.7391
.8	275.8324	7708.84	676836.152	6054.5149
.9	276.1466	7726.41	679151.439	6068.3224
88	276.4608	7744	681472	6082.1376
.1	276.7749	7761.61	683797.841	6095.9684
.2	277.0891	7779.24	686128.968	6109.8150
.3	277.4032	7796.89	688465.387	6123.6774
.4	277.7174	7814.56	690807.104	6137.5554
.5	278 0316	7832.25	693154.122	6151.4491
.6	278.3457	7849.96	695506.456	6165.3585
.7	278.6599	7867.69	697864.103	6179.2837
.8	278.9750	7885.44	700227.072	6193.2245
.9	279.2882	7903.21	702595.369	6207.1811
89	279.6024	7921	704969	6221.1534
.1	279.9165	7938.81	707347.971	6235.1413
.2	280.2307	7956.64	709732.288	6249.1450
.3	280.5448	7974.49	712121.957	6263.1644
.4	280.8590	7992.36	714516.984	6277.1995
.5	281.1732	8010.25	716917.375	6291.2035
.6	281.4873	8028.16	719323.136	6305.3168
.7	281.8825	8046.09	721734.273	6319.3990
.8	282.1156	8064.04	724150.792	6333.4970
.9	282.4298	8082.01	726572.699	6347.6813

Diam.	*Circum.*	*Square.*	*Cube.*	*Area.*
90	282.7440	8100	729000	6361.7400
.1	283.0581	8118.01	731432.701	6375.8850
.2	283.3723	8136 04	733870.808	6390.0458
.3	283.6864	8154.09	736314.327	6404.2222
.4	284.0006	8172.16	738763.264	6418 4144
.5	284.3148	8190.25	741217.625	6432.6223
.6	284.6289	8208 36	743677.416	6446 8474
.7	284.9431	8226.49	746142.643	6461.0852
.8	285.2572	8244 64	748613.312	6475.3402
.9	285.5714	8262.81	751089.429	6489.6109
91	285.8856	8281	753571	6503.8974
.1	286.1997	8299.21	756058 031	6518.1995
.2	286.5139	8317.44	758550.528	6532.5173
.3	286.8290	8335.69	761048.497	6546 8909
.4	287.1422	8353.96	763551.944	6561.2081
.5	287.4564	8372.25	766060.875	6575.5651
.6	287.7705	8390.56	768575.296	6589.9458
.7	288.0847	8408.89	771095 213	6604.3222
.8	288.3988	8427.24	773620.632	6618.7542
.9	288.7130	8445.61	776151.559	6633.1820
92	289.0272	8464	778688	6647.6256
.1	289.3413	8482.41	781229.961	6662.0848
.2	289.6555	8500.84	783777.448	6676.5597
.3	289.9696	8519.29	786330 467	6691.0161
.4	290.2838	8537.76	788889.024	6705.5567
.5	290.5980	8556.25	791453.125	6720.0787
.6	290.9121	8574 76	794022.776	6734.6165
.7	291.2263	8593.29	796597.983	6749.1699
.8	291.5404	8611.84	799178.752	6763.7391
.9	291.8546	8630.41	801765.089	6778.3240
93	292.1688	8649	804357	6792.9246
.1	292.4829	8667.61	806954 491	6807.5408
.2	292.7971	8686.24	809557.563	6822.1730
.3	293.1112	8704.89	812166.237	6836.8206
.4	293.4254	8723.56	814780.504	6851.4840
.5	293.7396	8742.25	817400 375	6866.1631
.6	294 0537	8760.96	820025.856	6880.8579
.7	294.3679	8779 69	822656.953	6895.5685
.8	294.6820	8798 44	825293.672	6910.2947
.9	294.9962	8817.21	827936.019	6925.0367
94	295.3104	8836	830584	6939.7944
.1	295.6245	8854.81	833237.621	6954.5677
.2	295.9387	8873.64	835896.888	6969.3568
.3	296.2436	8892.49	838561.807	6984.1614
.4	296.5670	8911.36	841232.384	6998 9821
.5	296.8812	8930.25	843908.625	7013.8183
.6	297.1953	8949.16	846590.536	7028.6702
.7	297.5095	8968.09	849278.123	7043.5025
.8	297.8236	8987.04	851971.392	7058.4180
.9	298.1378	9006.01	854670.349	7073.3202

Diam.	Circum.	Square.	Cube.	Area
95	298.4520	9025	857375	7088.2350
.1	298.7661	9044.01	860085.351	7103.1654
.2	299.0723	9063.04	862801.408	7118.1116
.3	299.3944	9082.09	865523.177	7133.0734
.4	299.7086	9101.16	868250.664	7148.0510
.5	300.0228	9120.25	870983.875	7163.0443
.6	300.3369	9139.36	873722.816	7178.0533
.7	300.6511	9158.49	876467.493	7193.0780
.8	300 9652	9177.64	879217.912	7208.1184
.9	301.2794	9196.81	881974.079	7223.1745
96	301.5936	9216	884736	7238.2464
.1	301.9077	9235.21	887503.681	7253.3339
.2	302.2219	9254.44	890277.128	7268.4371
.3	302.5360	9273.69	893056.347	7283.5561
.4	302.8502	9292.96	895841.344	7298.6907
.5	303.1644	9312.25	898632.125	7313.8411
.6	303.4785	9331.56	901428.696	7329.0072
.7	303.7927	9350.89	904231.063	7344.1890
.8	304.1068	9370.24	907039.232	7359.3864
.9	304.4210	9389.61	909853.209	7374.5996
97	304.7352	9409	912673	7389 8286
.1	305.0493	9428.41	915498.611	7405 0732
.2	305.3635	9447.84	918330.048	7420.3335
.3	305.6776	9467.29	921167.317	7435.6095
.4	305.9918	9486.76	924010.424	7450.9013
.5	306.3060	9506.25	926859.375	7466.2087
.6	306.6201	9525.76	929714.176	7481.5319
.7	306.9363	9545.29	932574.833	7496.8707
.8	307.2484	9564.84	935441.352	7512.2253
.9	307.5626	9584.41	938313.739	7527.5956
98	307.8768	9604	941192	7542 9816
.1	308.1909	9623.61	944076.141	7558.3832
.2	308 5051	9643.24	946966.168	7573.8006
.3	308.8192	9662.89	949862.087	7589.2338
.4	309 1334	9682.56	952763.904	7604.6826
.5	309.4476	9702.25	955671.625	7620.1471
.6	309.7617	9721.96	958585.256	7635.6273
.7	310.0759	9741.69	961504.803	7651.1933
.8	310.3960	9761.44	964430.272	7666.6349
.9	310.7042	9781.21	967361.669	7682.1623
99	311.0184	9801	970299	7697.7054
.1	311.3325	9820.81	973242.271	7713.2641
.2	311.6467	9840.64	976191.488	7728.8386
.3	311.9608	9860.49	979146.657	7744.4288
.4	312.2750	9880.36	982107.784	7760.0347
.5	312.5892	9900.25	985074.875	7775.6563
.6	312.9033	9920.16	988047.936	7791.2936
.7	313.2175	9940.09	991026.973	7806.9466
.8	313.5116	9960.04	994011.992	7822.6154
.9	313.8458	9980.01	997002.999	7838.2998
100	*314.1600*	10000	1000000	7854.0000

TABLE

Containing the circumferences and areas of circles, from one-eighth to 100 inches, advancing by an eighth.

Diam.	Circum.	Area.	Diam.	Circum.	Area.
			5 in.	15.7080	19.6350
⅛	.3927	.0122	⅛	16.1007	20.6290
¼	.7854	.0490	¼	16.4934	21.6475
⅜	1.1781	.1104	⅜	16.8861	22.6907
½	1.5708	.1963	½	17.2788	23.7583
⅝	1.9635	.3068	⅝	17.6715	24.8505
¾	2.3562	.4417	¾	18.0642	25.9672
⅞	2.7489	.6013	⅞	18.4569	27.1085
1 in.	3.1416	.7854	*6 in.*	18.8496	28.2744
⅛	3.5343	.9940	⅛	19.2423	29.4647
¼	3.9270	1.2271	¼	19.6350	30.6796
⅜	4.3197	1.4848	⅜	20.0277	31.9192
½	4.7124	1.7671	½	20.4204	33.1831
⅝	5.1051	2.0739	⅝	20.8131	34.4717
¾	5.4978	2.4052	¾	21.2058	35.7847
⅞	5.8905	2.7611	⅞	21.5985	37.1224
2 in.	6.2832	3.1416	*7 in.*	21.9912	38.4846
⅛	6.6759	3.5465	⅛	22.3839	39.8713
¼	7.0686	3.9760	¼	22.7766	41.2825
⅜	7.4613	4.4302	⅜	23.1693	42.7184
½	7.8540	4.9087	½	23.5620	44.1787
⅝	8.2467	5.4119	⅝	23.9547	45.6636
¾	8.6394	5.9395	¾	24.3474	47.1730
⅞	9.0321	6.4918	⅞	24.7401	48.7070
3 in.	9.4248	7.0686	*8 in.*	25.1328	50.2656
⅛	9.8175	7.6699	⅛	25.5255	51.8486
¼	10.2102	8.2957	¼	25.9182	53.4562
⅜	10.6029	8.9462	⅜	26.3109	55.0885
½	10.9956	9.6211	½	26.7036	56.7451
⅝	11.3883	10.3206	⅝	27.0963	58.4264
¾	11.7810	11.0446	¾	27.4890	60.1321
⅞	12.1737	11.7932	⅞	27.8817	61.8625
4 in.	12.5664	12.5664	*9 in.*	28.2744	63.6174
⅛	12.9591	13.3640	⅛	28.6671	65.3968
¼	13.3518	14.1862	¼	29.0598	67.2007
⅜	13.7445	15.0331	⅜	29.4525	69.0293
½	14.1372	15.9043	½	29.8452	70.8823
⅝	14.5299	16.8001	⅝	30.2379	72.7599
¾	14.9226	17.7205	¾	30.6306	74.6620
⅞	15.3153	18.6655	⅞	31.0233	76.5887

Diam.	*Circum.*	*Area.*	*Diam.*	*Circum.*	*Area.*
10 *in.*	31.4160	78.5400	16 *in.*	50.2656	201.0624
⅛	31.8087	80.5154	⅛	50.6583	204.2162
¼	32.2014	82.5160	¼	51.0510	207.3946
⅜	32.5941	84.5409	⅜	51.4437	210.5976
½	32.9868	86.5903	½	51.8364	213 8251
⅝	33.3795	88 6643	⅝	52.2291	217.0772
¾	33.7722	90.7627	¾	52.6218	220.3537
⅞	34.1649	92.8858	⅞	53.0145	223.6549
11 *in.*	34.5576	95.0334	17 *in.*	53.4072	226.9806
⅛	34.9503	97.2055	⅛	53.7999	230.3308
¼	35.3430	99.4021	¼	54.1926	233.7055
⅜	35.7357	101.6234	⅜	54.5853	237.1049
½	36.1284	103.8691	½	54.9780	240.5287
⅝	36.5211	106.1394	⅝	55.3707	243 9771
¾	36.9138	108.4342	¾	55.7634	247 4500
⅞	37.3065	110 7536	⅞	56.1561	250 9475
12 *in.*	37.6992	113.0976	18 *in.*	56.5488	254.4696
⅛	38.0919	115.4660	⅛	56.9415	258.0161
¼	38.4846	117.8590	¼	57.3342	261 5872
⅜	38.8773	120.2766	⅜	57.7269	265 1829
½	39.2700	122.7187	½	58.1196	268.8031
⅝	39.6627	125.1854	⅝	58.5123	272 4479
¾	40.0554	127.6765	¾	58.9050	276.1171
⅞	40.4481	130.1923	⅞	59.2977	279.8110
13 *in.*	40.8408	132.7326	19 *in.*	59.6904	283.5294
⅛	41.2335	135.2974	⅛	60.0831	287.2723
¼	41.6262	137.8867	¼	60 4758	291.0397
⅜	42.0189	140.5007	⅜	60.8685	294.8312
½	42.4116	143.1391	½	61.2612	298.6483
⅝	42.8043	145.8021	⅝	61.6539	302.4894
¾	43.1970	148.4896	¾	62.0466	306.3550
⅞	43.5897	151.2017	⅞	62.4393	310.2452
14 *in.*	43.9824	153.9384	20 *in.*	62.8320	314.1600
⅛	44.3751	156 6995	⅛	63.2247	318 0992
¼	44.7678	159.4852	¼	63.6174	322.0630
⅜	45.1605	162.2956	⅜	64.0101	326.0514
½	45.5532	165.1303	½	64.4028	330.0643
⅝	45 9459	167.9896	⅝	64.7955	334.1018
¾	46.3386	170.8735	¾	65.1882	338.1637
⅞	46.7313	173.7820	⅞	65.5809	342.2503
15 *in.*	47.1240	176.7150	21 *in.*	65 9736	346.3614
⅛	47.5167	179.6725	⅛	66.3663	350.4970
¼	47.9094	182.6545	¼	66.7590	354.6571
⅜	48.3021	185.6612	⅜	67.1517	358.8419
½	48.6948	188.6923	½	67.5444	363.0511
⅝	49.0875	191.7480	⅝	67.9371	367.2849
¾	49.4802	194.8282	¾	68.3298	371.5432
⅞	49.8729	197.9330	⅞	68.7225	375.8261

Diam.	Circum	Area.	Diam.	Circum.	Area.
22 *in.*	69.1152	380.1336	28 *in.*	87.9648	615.7536
⅛	69.5079	384.4655	⅛	88.3575	621.2636
¼	69.9006	388.8220	¼	88.7502	626.7982
⅜	70.2933	393.2031	⅜	89.1429	632.3574
½	70.6860	397.6087	½	89.5356	637.9411
⅝	71.0787	402.0388	⅝	89.9283	643.5494
¾	71.4714	406.4935	¾	90.3210	649.1821
⅞	71.8641	410.9728	⅞	90.7137	654.8395
23 *in.*	72.2568	415.4766	29 *in.*	91.1064	660.5214
⅛	72.6495	420.0049	⅛	91.4991	666.2278
¼	73.0422	424.5577	¼	91.8918	671.9587
⅜	73.4349	429.1352	⅜	92.2845	677.7143
½	73.8276	433.7371	½	92.6772	683.4943
⅝	74.2203	438.3636	⅝	93.0699	689.2989
¾	74.6130	443.0146	¾	93.4626	695.1280
⅞	75.0057	447.6902	⅞	93.8553	700.9817
24 *in.*	75.3984	452.3904	30 *in.*	94.2480	706.8600
⅛	75.7911	457.1150	⅛	94.6407	712.7627
¼	76.1838	461.8642	¼	95.0334	718.6900
⅜	76.5765	466.6380	⅜	95.4261	724.6419
½	76.9692	471.4363	½	95.8188	730.6183
⅝	77.3619	476.2592	⅝	96.2115	736.6193
¾	77.7546	481.1065	¾	96.6042	742.6447
⅞	78.1473	485.9785	⅞	96.9969	748.6948
25 *in.*	78.5400	490.8750	31 *in.*	97.3896	754.7694
⅛	78.9327	495.7960	⅛	97.7823	760.8685
¼	79.3254	500.7415	¼	98.1750	766.9921
⅜	79.7181	505.7117	⅜	98.5677	773.1404
½	80.1108	510.7063	½	98.9604	779.3131
⅝	80.5035	515.7255	⅝	99.3531	785.5104
¾	80.8962	520.7692	¾	99.7458	791.7322
⅞	81.2889	525.8375	⅞	100.1385	797.9786
26 *in.*	81.6816	530.9304	32 *in.*	100.5312	804.2496
⅛	82.0743	536.0477	⅛	100.9239	810.5450
¼	82.4670	541.1896	¼	101.3166	816.8650
⅜	82.8597	546.3561	⅜	101.7093	823.2096
½	83.2524	551.5471	½	102.1020	829.5787
⅝	83.6451	556.7627	⅝	102.4947	835.9724
¾	84.0378	562.0027	¾	102.8874	842.3905
⅞	84.4305	567.2674	⅞	103.2801	848.8333
27 *in.*	84.8232	572.5566	33 *in.*	103.6728	855.3006
⅛	85.2159	577.8703	⅛	104.0655	861.7924
¼	85.6086	583.2085	¼	104.4582	868.3087
⅜	86.0013	588.5714	⅜	104.8509	874.8497
½	86.3940	593.9587	½	105.2436	881.4151
⅝	86.7867	599.3706	⅝	105.6363	888.0051
¾	87.1794	604.8070	¾	106.0290	894.6196
⅞	87.5721	610.2680	⅞	106.4217	901.2587

Diam.	Circum.	Area.	Diam.	Circum.	Area.
34 *in.*	106.8144	907.9224	40 *in.*	125.6640	1256.6400
⅛	107.2071	914.6105	⅛	126.0567	1264.5062
¼	107.5998	921.3232	¼	126 4494	1272.3970
⅜	107.9925	928.0605	⅜	126.8421	1280.3124
½	108.3852	934.8223	½	127.2348	1288.2523
⅝	108 7779	941.6087	⅝	127.6275	1296.2168
¾	109.1706	948.4195	¾	128.0202	1304.2057
⅞	109.5633	955.2550	⅞	128.4129	1312.2193
35 *in.*	109.9560	962.1150	41 *in.*	128.8056	1320.2574
⅛	110.3487	968.9995	⅛	129.1983	1328.3200
¼	110.7414	975.9085	¼	129.5910	1336.4071
⅜	111.1341	982.8422	⅜	129.9837	1344.5189
½	111 5268	989.8003	½	130 3764	1352.6551
⅝	111.9195	996.7830	⅝	130.7691	1360.8159
¾	112.3122	1003.7902	¾	131.1618	1369.0012
⅞	112.7049	1010.8220	⅞	131.5545	1377.2111
36 *in.*	113.0977	1017.8784	42 *in.*	131 9472	1385.4456
⅛	113.4903	1024.9592	⅛	132.3399	1393.7045
¼	113 8830	1032 0646	¼	132.7326	1401.9880
⅜	114.2757	1039.1946	⅜	133 1253	1410.2961
½	114.6684	1046.3491	½	133 5180	1418.6287
⅝	115 0611	1053.5281	⅝	133.9107	1426.9859
¾	115.4538	1060.7317	¾	134.3034	1435.3675
⅞	115.8465	1067.9599	⅞	134.6961	1443.7738
37 *in.*	116.2392	1075.2126	43 *in.*	135.0888	1452.2046
⅛	116.6319	1082.4898	⅛	135.4815	1460.6599
¼	117.0246	1089 7915	¼	135.8742	1469.1397
⅜	117.4173	1097.1179	⅜	136.2669	1477.6342
½	117.8100	1104.4687	½	136.6596	1486.1731
⅝	118.2027	1111.8441	⅝	137.0523	1494.7266
¾	118.5954	1119.2440	¾	137.4450	1503.3046
⅞	118.9881	1126.6685	⅞	137.8377	1511.9072
38 *in.*	119.3808	1134.1176	4 *in.*	138.2304	1520 5344
⅛	119.7735	1141.5911	⅛	138.6231	1529.1860
¼	120.1662	1149.0892	¼	139.0158	1537.8622
⅜	120.5589	1156.6119	⅜	139 4085	1546.5530
½	120.9516	1164.1591	½	139.8012	1555.2883
⅝	121.3443	1171.7309	⅝	140.1939	1564.0382
¾	121.7370	1179.3271	¾	140.5866	1572.8125
⅞	122.1297	1186.9480	⅞	140.9793	1581.6115
39 *in.*	122.5224	1194.5934	45 *in.*	141.3720	1590.4350
⅛	122 9151	1202.2633	⅛	141.7647	1599.2830
¼	123.3078	1209.9577	¼	142.1574	1608.1555
⅜	123.7005	1217.6768	⅜	142.5505	1617.0427
½	124.0932	1225.4203	½	142.9428	1625.9743
⅝	124.4859	1233.1884	⅝	143.3355	1634.9205
¾	124.8786	1240.9810	¾	143.7282	1643.8912
⅞	125.2713	1248.7982	⅞	144.1209	1652.8865

Diam.	*Circum.*	*Area.*	*Diam.*	*Circum.*	*Area.*
46 *in.*	144.5136	1661.9064	52 *in.*	163.3632	2123.7216
⅛	144 9063	1670.9507	⅛	163.7559	2133.9440
¼	145 2990	1680.0196	¼	164.1486	2144.1910
⅜	145.6917	1689.1031	⅜	164.5413	2154.4626
½	146.0844	1698 2311	½	164.9340	2164.7587
⅝	146.4771	1707.3737	⅝	165 3267	2175.0794
¾	146.8698	1716.5407	¾	165 7194	2185.4245
⅞	147.2625	1725 7324	⅞	166.1121	2195.7943
47 *in.*	147.6552	1734.9486	53 *in.*	166.5048	2206.1886
⅛	148.0479	1744.1893	⅛	166.8975	2216.6074
¼	148.4406	1753.4545	¼	167.2902	2227 0507
⅜	148 8333	1762.7344	⅜	167.6829	2237.5187
½	149.2260	1772.0587	½	168.0756	2248.0111
⅝	149 6187	1781.3976	⅝	168.4683	2258.5281
¾	150.0114	1790.7610	¾	168 8610	2269 0696
⅞	150.4041	1800.1490	⅞	169.2537	2279.6357
48 *in.*	150.7968	1809.5616	54 *in.*	169.6464	2290.2264
⅛	151.1895	1818.9986	⅛	170.0391	2300.8415
¼	151.5822	1828.4602	¼	170.4318	2311.4812
⅜	151.9749	1837.9364	⅜	170.8245	2322.1455
½	152.3676	1847.4571	½	171.2172	2332.8343
⅝	152.7603	1856.9924	⅝	171.6099	2343.5477
¾	153.1530	1866.5521	¾	172 0026	2354.2855
⅞	153.5457	1876.1365	⅞	172.3953	2365.0480
49 *in.*	153.9384	1885.7454	55 *in.*	172 7880	2375.8350
⅛	154.3311	1895.3788	⅛	173.1807	2386.6465
¼	154.7238	1905.0367	¼	173.5734	2397.4825
⅜	155.1165	1914.7093	⅜	173.9661	2408.3432
½	155.5092	1924.4263	½	174.3588	2419.2283
⅝	155.9019	1934 1579	⅝	174.7515	2430.1830
¾	156 2946	1943.9140	¾	175.1442	2441.0722
⅞	156.6873	1953.6947	⅞	175.5369	2452.0310
50 *in.*	157.0800	1963.5000	56 *in.*	175.9296	2463.0144
⅛	157.4727	1973.3297	⅛	176.3223	2474.0222
¼	157.8654	1983.1840	¼	176.7150	2485.0546
⅜	158.2581	1993.0529	⅜	177.1077	2496.1116
½	158.6508	2002.9663	½	177.5004	2507.1931
⅝	159.0435	2012.8943	⅝	177.8931	2518.2992
¾	159.4362	2022.8467	¾	178.2858	2529.4297
⅞	159.8289	2032.8238	⅞	178.6785	2540.5849
51 *in.*	160.2216	2042.8254	57 *in.*	179.0712	2551.7646
⅛	160 6143	2052.8515	⅛	179.4639	2562.9688
¼	161.0070	2062.9021	¼	179.8566	2574.1975
⅜	161 3997	2072.9674	⅜	180.2493	2585.4509
½	161.7924	2083.0771	½	180.6420	2596.7287
⅝	162.1851	2093.2014	⅝	181.0347	2608.0311
¾	162.5778	2103.3502	¾	181.4274	2619 3580
⅞	102.9705	2113.5236	⅞	181.8201	2630.7095

Dim.	*Circum.*	*Area.*	*Diam.*	*Circum.*	*Area.*
58 *in.*	182.2128	2642.0856	64 *in.*	201.0624	3216.9984
⅛	182.6055	2653.4861	⅛	201.4551	3229.5770
¼	182.9982	2664.9112	¼	201.8478	3242.1782
⅜	183.3909	2676.3609	⅜	202.2405	3254.8080
½	183.7836	2687.8351	½	202.6332	3267.4603
⅝	184.1763	2699.3338	⅝	203.0259	3280.1372
¾	184.5690	2710.8571	¾	203.4186	3292.8385
⅞	184.9617	2722.4050	⅞	203.8113	3305.5645
59 *in.*	185.3544	2733.9774	65 *in.*	204.2040	3318.3150
⅛	185.7471	2745.5743	⅛	204.5967	3331.0900
¼	186.1398	2757.1957	¼	204.9894	3343.8875
⅜	186.5325	2768.8418	⅜	205.3821	3356.7137
½	186.9252	2780.5123	½	205.7748	3369.5623
⅝	187.3179	2792.2074	⅝	206.1675	3382.4355
¾	187.7106	2803.9270	¾	206.5602	3395.3332
⅞	188.1033	2815.6712	⅞	206.9529	3408.2555
60 *in.*	188.4960	2827.4400	66 *in.*	207.3456	3421.2024
⅛	188.8887	2839.2332	⅛	207.7383	3434.1737
¼	189.2814	2851.0510	¼	208.1310	3447.1676
⅜	189.6741	2862.8934	⅜	208.5237	3460.1901
½	190.0668	2874.7603	½	208.9164	3473.2351
⅝	190.4595	2886.6517	⅝	209.3091	3486.3047
¾	190.8522	2898.5677	¾	209.7018	3499.3987
⅞	191.2449	2910.5083	⅞	210.0945	3512.5174
61 *in.*	191.6376	2922.4734	67 *in.*	210.4872	3525.6606
⅛	192.0303	2934.4630	⅛	210.8799	3538.8283
¼	192.4230	2946.4771	¼	211.2726	3552.0185
⅜	192.8157	2958.5159	⅜	211.6653	3565.2374
½	193.2084	2970.5791	½	212.0580	3578.4787
⅝	193.6011	2982.6669	⅝	212.4507	3591.7446
¾	193.9938	2994.7792	¾	212.8434	3605.0350
⅞	194.3865	3006.9161	⅞	213.2361	3618.3500
62 *in.*	194.7792	3019.0776	68 *in.*	213.6288	3631.6896
⅛	195.1719	3031.2635	⅛	214.0215	3645.0536
¼	195.5646	3043.4740	¼	214.4142	3658.4402
⅜	195.9573	3055.7091	⅜	214.8069	3671.8554
½	196.3500	3067.9687	½	215.1996	3685.2931
⅝	196.7427	3080.2529	⅝	215.5923	3698.7554
¾	197.1354	3092.5615	¾	215.9850	3712.2421
⅞	197.5281	3104.8948	⅞	216.3777	3725.7535
63 *in.*	197.9208	3117.2526	69 *in.*	216.7704	3739.2894
⅛	198.3135	3129.6349	⅛	217.1631	3752.8498
¼	198.7062	3142.0417	¼	217.5558	3766.4327
⅜	199.0989	3154.4732	⅜	217.9485	3780.0443
½	199.4916	3166.9291	½	218.3412	3793.6783
⅝	199.8843	3179.4096	⅝	218.7339	3807.3369
¾	200.2770	3191.9146	¾	219.1266	3821.0200
⅞	200.6697	3204.4442	⅞	219.5193	3834.7277

Diam.	*Circum.*	*Area.*	*Diam.*	*Circum.*	*Area.*
70 *in.*	219.9120	3848.4600	76 *in.*	238.7616	4536.4704
⅛	220.3047	3862.2167	⅛	239.1543	4551.4023
¼	220.6974	3875 9960	¼	239.5470	4566.3626
⅜	221.0901	3889 8039	⅜	239.9397	4581.3486
½	221.4828	3903.6343	½	240.3324	4596.3571
⅝	221.8755	3917.4893	⅝	240.7251	4611.3902
¾	222.2682	3931.3687	¾	241.1178	4626.4477
⅞	222.6609	3945.2728	⅞	241.5105	4641.5299
71 *in.*	223.0536	3959.2014	77 *in.*	241.9032	4656.6366
⅛	223.4463	3973.1545	⅛	242.2959	4671.7678
¼	223.8390	3987.1301	¼	242.6866	4686.9215
⅜	224.2317	4001.1344	⅜	243.0813	4702.1039
½	224 6244	4015.1611	½	243.4740	4717.3087
⅝	225.0171	4029.2124	⅝	243.8667	4732.5381
¾	225.4098	4043 2882	¾	244.2594	4747.7920
⅞	225.8025	4057.3886	⅞	244.6521	4763.0705
72 *in.*	226.1952	4071.5136	78 *in.*	245.0448	4778.3736
⅛	226.5879	4085.6631	⅛	245.4375	4793.7012
¼	226.9806	4099 8350	¼	245.8302	4809.0512
⅜	227.3733	4114.0356	⅜	246.2229	4824.4299
½	227.7660	4128.2587	½	246.6156	4839.8311
⅝	228.1587	4142 5064	⅝	247.0083	4855.2568
¾	228.5514	4156.7785	¾	247.4010	4870.7071
⅞	228.9441	4171.0753	⅞	247.7937	4886.1820
73 *in.*	229.3368	4185.3966	79 *in.*	248.1864	4901.6814
⅛	229 7295	4199.7424	⅛	248.5791	4917.2053
¼	230.1222	4214.1107	¼	248.9718	4932.7517
⅜	230.5149	4228 5077	⅜	249.3645	4948.3268
½	230.9076	4242 9271	½	249.7572	4963.9243
⅝	231.3003	4257.3711	⅝	250.1499	4979.5456
¾	331.6930	4271.8396	¾	250.5426	4995.1930
⅞	232.0857	4286.3327	⅞	250.9353	5010.8642
74 *in.*	232.4784	4300.8504	80 *in.*	251.3280	5026.5600
⅛	232.8711	4315 3926	⅛	251.7207	5042.2803
¼	233.2638	4329.9572	¼	252.1134	5058.0230
⅜	233.6565	4344.5505	⅜	252.5061	5073.7944
½	234.0492	4359.1663	½	252.8988	5089.5883
⅝	234.4419	4373.8067	⅝	253.2915	5105.4060
¾	234.8346	4388.4715	¾	253.6842	5121.2497
⅞	235.2273	4403.1610	⅞	254.0769	5137.1173
75 *in.*	235.6200	4417.8750	81 *in.*	254.4696	5153.0094
⅛	236.0127	4432.6135	⅛	254.8623	5168.9260
¼	236.4054	4447.3745	¼	255.2550	5184.8651
⅜	236.7981	4462.1642	⅜	255.6477	5200.8329
½	237.1908	4476.9763	½	256.0404	5216.8231
⅝	237.5835	4491.8130	⅝	256.4381	5232.8371
¾	237.9762	4506.6742	¾	256.8258	5248.8772
⅞	238.3689	4521.5600	⅞	257.2185	5264.9411

Diam.	*Circum.*	*Area.*	*Diam.*	*Circum.*	*Area.*
82 *in.*	257.6112	5281.0296	88 *in.*	276.4608	6082 1376
⅛	258.0039	5297.1426	⅛	276.8535	6099.4287
¼	258.3866	5313.2780	¼	277.2462	6116.7422
⅜	258.7993	5329.4421	⅜	277.6389	6134.0844
½	259.1820	5345.6287	½	278.0316	6151.4491
⅝	259.5747	5361.8391	⅝	278.4243	6168.8376
¾	259.9674	5378.0755	¾	278.8170	6186.2521
⅞	260.3601	5294.3358	⅞	279.2097	6203.6905
83 *in.*	260.7528	5410.6206	89 *in.*	279.6024	6221.1534
⅛	261.1455	5426.9299	⅛	279.9951	6238.6408
¼	261.5382	5443 2617	¼	280.3878	6256.1507
⅜	261.9309	5459.6222	⅜	280 7805	6273.6893
½	262.3236	5476.0051	½	281.1732	6291.2503
⅝	262.7163	5492.4118	⅝	281.5659	6308.8351
¾	263.1090	5508.8446	¾	281.9586	6326.4460
⅞	263.5017	5525.3012	⅞	282.3513	6344.0807
84 *in.*	263.8944	5541.7824	90 *in.*	282.7440	6361.7400
⅛	264 2871	5558.2881	⅛	283.1367	6379.4238
¼	264.6798	5574.8162	¼	283.5294	6397.1300
⅜	265.0725	5591.3730	⅜	283.9221	6414.8649
½	265.4652	5607.9523	½	284.3148	6432 6223
⅝	265.8579	5624.5554	⅝	284.7075	6450.4039
¾	266 2506	5641.1845	¾	285.1002	6468.2107
⅞	266.6433	5657.8357	⅞	285.4929	6486.0418
85 *in.*	267.0360	5674.5150	91 *in.*	285.8856	6503.8974
⅛	267.4287	5691.2170	⅛	286.2783	6521.7775
¼	267.8214	5707.9415	¼	286 6710	6539.6801
⅜	268.2141	5724.6947	⅜	287.0637	6557.6114
½	268.6068	5741.4703	½	287.4564	6575.5651
⅝	268.9995	5758.2697	⅝	287.8491	6593.5431
¾	269.3922	5775.0952	¾	288.2418	6611.5462
⅞	269.7849	5791 9445	⅞	288.6345	6629.5736
86 *in.*	270.1776	5808.8184	92 *in.*	289.0272	6647.6258
⅛	270.5703	5825.7168	⅛	289.4199	6665.7021
¼	270.9630	5842.6376	¼	289.8126	6683.8010
⅜	271.3557	5859.5871	⅜	290.2053	6701.9286
½	271.7484	5876.5591	½	290.5980	6720.0787
⅝	272.1411	5893.5549	⅝	290.9907	6738.2530
¾	272.5338	5910.5767	¾	291.3834	6756.4525
⅞	272.9265	5927.5224	⅞	291.7761	6774 6763
87 *in.*	273.3192	5944.6926	93 *in.*	292.1688	6792.9248
⅛	273.7119	5961.7873	⅛	292.5615	6811.1974
¼	274.1046	5978.9045	¼	292.9542	6829.4927
⅜	274 4973	5996.0504	⅜	293.3469	6847.8167
½	274.8900	6013.2187	½	293.7396	6866.1631
⅝	275.2827	6030 4108	⅝	294.1323	6884.5338
¾	275.6754	6047.6290	¾	294.5250	6902.9296
⅞	276.0681	6064.8710	⅞	294.9177	6921 3497

Diam.	*Circum.*	*Area.*	*Diam.*	*Circum.*	*Area.*
94 *in.*	295.3104	6939.7946	97 *in.*	304.7352	7389.8288
⅛	295.7031	6958.2636	⅛	305.1279	7408.8868
¼	296.0958	6976.7552	¼	305.5206	7427.9675
⅜	296.4885	6995.2755	⅜	305.9133	7447.0769
½	296.8812	7013.8183	½	306.3060	7466.2087
⅝	297.2739	7032.3853	⅝	306.6987	7485.3648
¾	297.6666	7050.9775	¾	307.0914	7504.5460
⅞	298.0593	7069.5940	⅞	307.4841	7523.7515
95 *in.*	298.4520	7088.2352	98 *in.*	307.8768	7542.9818
⅛	298.8447	7106.9005	⅛	308.2695	7562.2362
¼	299.2374	7125.5885	¼	308.6622	7581.5132
⅜	299.6301	7144.3052	⅜	309.0549	7600.8189
½	300.0228	7163.0443	½	309.4476	7620.1471
⅝	300.4155	7181.8077	⅝	309.8403	7639.4995
¾	300.8082	7200.5962	¾	310.2230	7658.8771
⅞	301.2009	7219.4090	⅞	310.6257	7678.2790
96 *in.*	301.5936	7238.2466	99 *in.*	311.0184	7697.7056
⅛	301.9863	7257.1083	⅛	311.4111	7717.1563
¼	302.3790	7275.9926	¼	311.8038	7736.6297
⅜	302.7717	7294.9056	⅜	312.1965	7756.1318
½	303.1644	7313.8411	½	312.5892	7775.6563
⅝	303.5571	7332.8008	⅝	312.9819	7795.2051
¾	303.9498	7351.7857	¾	313.3746	7814.7790
⅞	304.3425	7370.7949	⅞	313.7673	7834.3772
			100 *in.*	314.1600	7854.0000

TABLE

Containing the circumferences and areas of circles from 1 *to* 50 *feet, and advancing by an inch.*

Diam.	*Circum.*	*Area.*	*Diam.*	*Circum.*	*Area.*
1 *ft.*	3.1416	.7854	4 *ft.*	12.5664	12.5664
1	3.4034	.9217	1	12.8282	13.0952
2	3.6652	1.0690	2	13.0900	13.6353
3	3.9270	1.2271	3	13.3518	14.1862
4	4.1888	1.3962	4	13.6136	14.7479
5	4.4506	1.5761	5	13.8754	15.3206
6	4.7124	1.7671	6	14.1372	15.9043
7	4.9742	1.9689	7	14.3990	16.4986
8	5.2360	2.1816	8	14.6608	17.1041
9	5 4978	2.4052	9	14 9226	17.7205
10	5 7596	2.6398	10	15 1844	18.3176
11	6.0214	3.8852	11	15.4462	18.9858
2 *ft.*	6.2832	3.1416	5 *ft.*	15.7080	19.6350
1	6.5450	3.4087	1	15 9698	20.2947
2	6.8068	3.6869	2	16.2316	20.9656
3	7.0686	3.9760	3	16 4934	21.6475
4	7.3304	4.2760	4	16.7552	22.3400
5	7.5922	4.5869	5	17.0170	23.0437
6	7.8540	4.9087	6	17.2788	23.7583
7	8 1158	5 2413	7	17.5406	24.4835
8	8 3776	5.5850	8	17 8024	25 2199
9	8.6394	5 9395	9	18 0642	25.9672
10	8.9012	6.3049	10	18 3260	26 7251
11	9.1630	6.6813	11	18.5878	27.4943
3 *ft.*	9.4248	7.0686	6 *ft.*	18 8496	28.2744
1	9.6866	7.4666	1	19.1114	29.0649
2	9.9484	7.8757	2	19.3732	29.8668
3	10.2102	8 2957	3	19.6350	30.6796
4	10.4720	8 7265	4	19 8968	31.5029
5	10.7338	9.1683	5	20.1586	32.3376
6	10 9956	9.6211	6	20.4204	33.1831
7	11 2574	10.0846	7	20.6822	34.0391
8	11.5192	10.5591	8	20.9440	34.9065
9	11.7810	11.0446	9	21.2058	35.7847
10	12.0428	11.5409	10	21.4676	36.6735
11	12.3046	12.0481	11	21.7294	37.5736

Diam.	*Circum.*	*Area.*	*Diam.*	*Circum.*	*Area.*
7 *ft.*	21.9912	38.4846	11 *ft.*	31.5576	95.0334
1	22.2530	39.4060	1	34.8194	96.4783
2	22.5148	40.3388	2	35.0812	97.9347
3	22.7766	41.2825	3	35.3430	99.4021
4	23.0384	42.2367	4	35.6048	100.8797
5	23.3002	43.2022	5	35.8666	102.3689
6	23.5620	44.1787	6	36.1284	103.8691
7	23.8238	45.1656	7	36.3902	105.3794
8	24.0856	46.1638	8	36.6520	106.9013
9	24.3474	47.1730	9	36.9138	108.4342
10	24.6092	48.1926	10	37.1756	109.9772
11	24.8710	49.2236	11	37.4374	111.5319
8 *ft.*	25.1328	50.2656	12 *ft.*	37.6992	113.0976
1	25.3946	51.3178	1	37.9610	114.6732
2	25.6564	52.3816	2	38.2228	116.2607
3	25.9182	53.4562	3	38.4846	117.8590
4	26.1800	54.5412	4	38.7464	119.4674
5	26.4418	55.6377	5	39.0082	121.0876
6	26.7036	56.7451	6	39.2700	122.7187
7	26.9654	57.8628	7	39.5318	124.3598
8	27.2272	58.9920	8	39.7936	126.0127
9	27.4890	60.1321	9	40.0554	127.6765
10	27.7508	61.2826	10	40.3172	129.3504
11	28.0126	62.4445	11	40.5790	131.0360
9 *ft.*	28.2744	63.6174	13 *ft.*	40.8408	132.7326
1	28.5362	64.8006	1	41.1026	134.4391
2	28.7980	65.9951	2	41.3644	136.1574
3	29.0598	67.2007	3	41.6262	137.8867
4	29.3216	68.4166	4	41.8880	139.6260
5	29.5834	69.6440	5	42.1498	141.3771
6	29.8452	70.8823	6	42.4116	143.1391
7	30.1070	72.1309	7	42.6734	144.9111
8	30.3688	73.3910	8	42.9352	146.6949
9	30.6306	74.6620	9	43.1970	148.4896
10	30.8924	75.9433	10	43.4588	150.2943
11	31.1542	77.2362	11	43.7206	152.1109
10 *ft.*	31.4160	78.5400	14 *ft.*	43.9824	153.9384
1	31.6778	79.8540	1	44.2442	155.7758
2	31.9396	81.1795	2	44.5060	157.6250
3	32.2014	82.5160	3	44.7678	159.4852
4	32.4632	83.8627	4	45.0296	161.3553
5	32.7250	85.2211	5	45.2914	163.2373
6	32.9868	86.5903	6	45.5532	165.1303
7	33.2486	87.9697	7	45.8150	167.0331
8	33.5104	89.3608	8	46.0768	168.9479
9	33.7722	90.7627	9	46.3386	170.8735
10	34.0340	92.1749	10	46.6004	172.8091
11	34.2958	93.5986	11	46.8622	174.7565

Diam.	Circum.	Area.	Diam.	Circum.	Area.
15 *ft.*	47.1240	176.7150	19 *ft.*	59.6904	283.5294
1	47.3858	178.6832	1	59.9522	286.0210
2	47.6476	180.6634	2	60.2140	288.5249
3	47.9094	182.6545	3	60.4758	291.0397
4	48.1712	184.6555	4	60.7376	293.5641
5	48.4330	186.6684	5	60.9994	296.1007
6	48.6948	188.6923	6	61.2612	298.6483
7	48.9566	190.7260	7	61.5230	301.2054
8	49.2184	192.7716	8	61.7848	303.7747
9	49.4802	194.8282	9	62.0466	306.3550
10	49.7420	196.8946	10	62.3084	308.9448
11	50.0038	198.9730	11	62.5702	311.5469
16 *ft.*	50.2656	201.0624	20 *ft.*	62.8320	314.1600
1	50.5274	203.1615	1	63.0938	316.7824
2	50.7892	205.2726	2	63.3556	319.4173
3	51.0510	207.3946	3	63.6174	322.0630
4	51.3128	209.5264	4	63.8792	324.7182
5	51.5746	211.6703	5	64.1410	327.3858
6	51.8364	213.8251	6	64.4028	330.0643
7	52.0982	215.9896	7	64.6646	332.7522
8	52.3600	218.1662	8	64.9264	335.4525
9	52 6218	220.3537	9	65.1882	338.1637
10	52.8836	222.5510	10	65.4500	340.8844
11	53.1454	224.7603	11	65.7118	343.6174
17 *ft.*	53.4072	226.9806	21 *ft.*	65.9736	346.3614
1	53.6690	229.2105	1	66.2354	349.1147
2	53.9308	231.4525	2	66.4972	351.8804
3	54.1926	233.7055	3	66.7590	354.6571
4	54.4544	235.9682	4	67.0208	357.4432
5	54.7162	238.2430	5	67.2826	360.2417
6	54.9780	240.5287	6	67.5444	363.0511
7	55.2398	242.8241	7	67.8062	365.8698
8	55.5016	245.1316	8	68.0680	368.7011
9	55.7634	247.4500	9	68.3298	371.5432
10	56.0252	249.7781	10	68.5916	374.3947
11	56.2870	252.1184	11	68.8534	377.2587
18 *ft.*	56.5488	254.4696	22 *ft.*	69.1152	380.1336
1	56.8106	256.8303	1	69.3770	383.0177
2	57.0724	259.2033	2	69.6388	385.9144
3	57.3342	261.5872	3	69.9006	388.8220
4	57.5960	263.9807	4	70.1624	391.7389
5	57.8578	266.3864	5	70.4242	394.6683
6	58.1196	268.8031	6	70.6860	397.6087
7	58.3814	271.2293	7	70.9478	400.5583
8	58.6432	273.6678	8	71.2096	403.5204
9	58.9050	276.1171	9	71.4714	406.4935
10	59.1668	278.5761	10	71.7332	409.4759
11	59.4286	281.0472	11	71.9950	412.4707

Diam.	*Circum.*	*Area.*	*Diam.*	*Circum.*	*Area.*
23 *ft.*	72.2568	415.4766	27 *ft.*	84.8232	572.5566
1	72.5186	418.4915	1	85.0850	576.0949
2	72.7804	421.5192	2	85.3468	579.6463
3	73.0422	424.5577	3	85.6086	583.2085
4	73.3040	427.6055	4	85.8704	586.7796
5	73.5658	430.6658	5	86.1322	590.3637
6	73.8276	433.7371	6	86.3940	593.9587
7	74.0894	436.8175	7	86.6558	597.5625
8	74.3512	439.9106	8	86.9176	601.1793
9	74.6130	443.0146	9	87.1794	604.8070
10	74.8748	446.1278	10	87.4412	608.4436
11	75.1366	449.2536	11	87.7030	612.0931
24 *ft.*	75.3984	452.3904	28 *ft.*	87.9648	615.7536
1	75.6602	455.5362	1	88.2266	619.4228
2	75.9220	458.6948	2	88.4884	623.1050
3	76.1838	461.8642	3	88.7502	626.7982
4	76.4456	465.0428	4	89.0120	630.5002
5	76.7074	468.2341	5	89.2738	634.2152
6	76.9692	471.4363	6	89.5356	637.9411
7	77.2310	474.6476	7	89.7974	641.6758
8	77.4928	477.8716	8	90.0592	645.4235
9	77.7546	481.1065	9	90.3210	649.1821
10	78.0164	484.3506	10	90.5828	652.9495
11	78.2782	487.6073	11	90.8446	656.7300
25 *ft.*	78.5400	490.8750	29 *ft.*	91.1064	660.5214
1	78.8018	494.1516	1	91.3682	664.3214
2	79.0636	497.4411	2	91.6300	668.1346
3	79.3254	500.7415	3	91.8918	671.9587
4	79.5872	504.0510	4	92.1536	675.7915
5	79.8490	507.3732	5	92.4154	679.6375
6	80.1108	510.7063	6	92.6772	683.4943
7	80.3726	514.0484	7	92.9390	687.3598
8	80.6344	517.4034	8	93.2008	691.2385
9	80.8962	520.7692	9	93.4626	695.1280
10	81.1580	524.1441	10	93.7244	699.0263
11	81.4198	527.5318	11	93.9862	702.9377
26 *ft.*	81.6816	530.9304	30 *ft.*	94.2480	706.8600
1	81.9434	534.3379	1	94.5098	710.7909
2	82.2052	537.7583	2	94.7716	714.7350
3	82.4670	541.1896	3	95.0334	718.6900
4	82.7288	544.6299	4	95.2952	722.6537
5	82.9906	548.0830	5	95.5570	726.6305
6	83.2524	551.5471	6	95.8186	730.6183
7	83.5142	555.0201	7	96.0806	734.6147
8	83.7760	558.5059	8	96.3424	738.6242
9	84.0378	562.0027	9	96.6042	742.6447
10	84.2996	565.5084	10	96.8660	746.6738
11	84.5614	569.0270	11	97.1278	750.7161

Diam.	*Circum.*	*Area.*	*Diam.*	*Circum.*	*Area.*
31 *ft.*	97.3896	754.7694	35 *ft.*	109.9560	962.1150
1	97.6514	758.8311	1	110.2178	966.7001
2	97.9132	762.9062	2	110.4796	971.2989
3	98.1750	766.9921	3	110.7414	975.9085
4	98.4368	771.0866	4	111.0032	980.5264
5	98.6986	775.1944	5	111.2650	985.1579
6	98.9604	779.3131	6	111.5268	989.8003
7	99.2222	783.4403	7	111.7886	994.4509
8	99.4840	787.5808	8	112.0504	999.1151
9	99.7458	791.7322	9	112.3122	1003.7902
10	100.0076	795.8922	10	112.5740	1008.4736
11	100.2694	800.0654	11	112.8358	1013.1705
32 *ft.*	100.5312	804.2496	36 *ft.*	113.0976	1017.8784
1	100.7930	808.4422	1	113.3594	1022.5944
2	101.0548	812.6481	2	113.6212	1027.3240
3	101.3166	816.8650	3	113.8830	1032.0646
4	101.5784	821.0904	4	114.1448	1036.8134
5	101.8402	825.3291	5	114.4066	1041.5758
6	102.1020	829.5787	6	114.6684	1046.3491
7	102.3638	833.8368	7	114.9302	1051.1306
8	102.6256	838.1082	8	115.1920	1055.9257
9	102.8874	842.3905	9	115.4538	1060.7317
10	103.1492	846.6813	10	115.7756	1065.5459
11	103.4110	850.9855	11	115.9774	1070.3738
33 *ft.*	103.6728	855.3006	37 *ft.*	116.2392	1075.2126
1	103.9346	859.6240	1	116.5010	1080.0594
2	104.1964	863.9609	2	116.7628	1084.9201
3	104.4582	868.3087	3	117.0246	1089.7915
4	104.7200	872.6649	4	117.2864	1094.6711
5	104.9818	877.0346	5	117.5482	1099.5644
6	105.2436	881.4151	6	117.8100	1104.4687
7	105.5054	885.8040	7	118.0718	1109.3810
8	105.7672	890.2064	8	118.3336	1114.3071
9	106.0290	894.6196	9	118.5954	1119.2440
10	106.2908	899.0413	10	118.8572	1124.1891
11	106.5526	903.4763	11	119.1190	1129.1478
34 *ft.*	106.8144	907.9224	38 *ft.*	119.3808	1134.1176
1	107.0762	912.3767	1	119.6426	1139.0953
2	107.3380	916.8445	2	119.9044	1144.0868
3	107.5998	921.3232	3	120.1662	1149.0892
4	107.8616	925.8103	4	120.4280	1154.0997
5	108.1234	930.3108	5	120.6898	1159.1239
6	108.3852	934.8223	6	120.9516	1164.1591
7	108.6470	939.3421	7	121.2134	1169.2023
8	108.9088	943.8753	8	121.4752	1174.2592
9	109.1706	948.4195	9	121.7370	1179.3271
10	109.4324	952.9720	10	121.9988	1184.4030
11	109.6942	957.5380	11	122.2606	1189.4927

Diam.	*Circum.*	*Area.*	*Diam.*	*Circum.*	*Area.*
39 *ft.*	122.5224	1194.5934	43 *ft.*	135.0888	1452.2046
1	122.7842	1199.7195	1	135.3506	1457.8365
2	123.0460	1204.8244	2	135.6124	1463.4827
3	123.3078	1209.9577	3	135.8742	1469.1397
4	123.5696	1215.0990	4	136.1360	1474.8044
5	123.8314	1220.2542	5	136.3978	1480.4833
6	124.0932	1225.4203	6	136.6596	1486.1731
7	124.3550	1230.5943	7	136.9214	1491.8705
8	124.6168	1235.7822	8	137.1832	1497.5821
9	124.8786	1240.9810	9	137.4450	1503.3046
10	125.1404	1246.1878	10	137.7068	1509.0348
11	125.4022	1251.4084	11	137.9686	1514.7791
40 *ft.*	125.6640	1256.6400	44 *ft.*	138.2304	1520.5344
1	125.9258	1261.8794	1	138.4922	1526.2971
2	126.1876	1267.1327	2	138.7540	1532.0742
3	126.4494	1272.3970	3	139.0158	1537.8622
4	126.7112	1277.6692	4	139.2776	1543.6578
5	126.9730	1282.9553	5	139.5394	1549.4676
6	127.2348	1288.2523	6	139.8012	1555.2883
7	127.4966	1293.5572	7	140.0630	1561.1165
8	127.7584	1298.8760	8	140.3248	1566.9591
9	128.0202	1304.2057	9	140.5866	1572.8125
10	128.2820	1309.5433	10	140.8484	1578.6735
11	128.5438	1314.8949	11	141.1102	1584.5488
41 *ft.*	128.8056	1320.2574	45 *ft.*	141.3720	1590.4350
1	129.0674	1325.6276	1	141.6338	1596.3286
2	129.3292	1331.0119	2	141.8956	1602.2366
3	129.5910	1336.4071	3	142.1574	1608.1555
4	129.8528	1341.8101	4	142.4192	1614.0819
5	130.1146	1347.2271	5	142.6810	1620.0226
6	130.3764	1352.6551	6	142.9428	1625.9743
7	130.6382	1358.0908	7	143.2046	1631.9334
8	130.9000	1363.5406	8	143.4664	1637.9068
9	131.1618	1369.0012	9	143.7282	1643.8912
10	131.4236	1374.4697	10	143.9900	1649.8831
11	131.6854	1379.9521	11	144.2518	1655.8892
42 *ft.*	131.9472	1385.4456	46 *ft.*	144.5136	1661.9064
1	132.2090	1390.2467	1	144.7754	1667.9308
2	132.4708	1396.4619	2	145.0372	1673.9698
3	132.7326	1401.9880	3	145.2990	1680.0196
4	132.9944	1407.5219	4	145.5608	1686.0769
5	133.2562	1413.0698	5	145.8226	1692.1485
6	133.5180	1418.6287	6	146.0844	1698.2311
7	133.7798	1424.1952	7	146.3462	1704.3210
8	134.0416	1429.7759	8	146.6080	1710.4254
9	134.3034	1435.3675	9	146.8698	1716.5407
10	134.5652	1440.9668	10	147.1316	1722.6634
11	134.8270	1446.5802	11	147.3934	1728.8005

Diam.	Circum.	Area.	Diam.	Circum.	Area.
47 *ft.*	147.6552	1734.9486	48 7	152.6294	1853.8087
1	147.9170	1741.1039	8	152.8912	1860.1750
2	148.1788	1747.2738	9	153.1530	1866.5521
3	148.4406	1753.4545	10	153.4148	1872.9365
4	148.7024	1759.6426	11	153.6766	1879.3355
5	148.9642	1765.8452	49 *ft.*	153.9384	1885.7454
6	149.2260	1772.0587	1	154.2002	1892.1724
7	149.4878	1778.2795	2	154.4620	1898.5041
8	149.7496	1784.5148	3	154.7238	1905.0367
9	150.0114	1790.7610	4	154.9856	1911.4965
10	150.2732	1797.0145	5	155.2474	1917.9609
11	150.5350	1803.2826	6	155.5092	1924.4263
48 *ft.*	150.7968	1809.5616	7	155.7710	1930.9188
1	151.0586	1815.8477	8	156.0328	1937.3159
2	151.3204	1822.1485	9	156.2946	1943.9140
3	151.5822	1828.4602	10	156.5564	1950.4392
4	151.8440	1834.7791	11	156.8182	1956.9691
5	152.1058	1841.1127	50 *ft.*	157.0800	1963.5000
6	152.3676	1847.4571			

TABLE XI,

Containing the superficies and solid content of spheres, from 1 *to* 12, *and advancing by a tenth.*

Diam.	Superficies.	Solidity.	Diam.	Superficies.	Solidity.
1.0	3.1416	.5236	2.5	19.6350	8.1812
.1	3.8013	.6969	.6	21.2372	9.2027
.2	4.5239	.9047	.7	22.9022	10.3060
.3	5.3093	1.1503	.8	24.6300	11.4940
.4	6.1575	1.4367	.9	26.4208	12.7700
.5	7.0686	1.7671	3.0	28.2744	14.1372
.6	8.0424	2.1446	.1	30.1907	15.5985
.7	9.0792	2.5724	.2	32.1699	17.1573
.8	10.1787	3.0536	.3	34.2120	18.8166
.9	11.3411	3.5913	.4	36.3168	20.5795
2.0	12.5664	4.1888	.5	38.4846	22.4493
.1	13.8544	4.8490	.6	40.7151	24.4290
.2	15.2053	5.5752	.7	43.0085	26.5219
.3	16.6190	6.3706	.8	45.3647	28.7309
.4	18.0956	7.2382	.9	47.7837	31.0594

Diam.	*Superficies.*	*Solidity.*	*Diam.*	*Superficies.*	*Solidity.*
4.0	50.2656	33.5104	8.0	201.0624	268.0832
.1	52.8102	36.0870	.1	206.1203	278.2625
.2	55.4178	38.7924	.2	211.2411	288.6962
.3	58.0881	41.6298	.3	216,4248	299.3876
.4	60.8213	44.6023	.4	221.6712	310.3398
.5	63.6174	47.7130	.5	226.9806	321.5558
.6	66.4782	50.9651	.6	232.3527	333.0389
.7	69.3979	54.3617	.7	237.7877	344.7921
.8	72.3824	57.9059	.8	243.2855	356.8187
.9	75.4298	61.6010	.9	248.8461	369.1217
5.0	78.5400	65.4500	9.0	254.4696	381.7044
.1	81.7130	69.4560	.1	260.1558	394.5697
.2	84.9488	73.6223	.2	265.9130	407.7210
.3	88.2475	77.9519	.3	271.7169	421.1613
.4	91.6090	82.4481	.4	277.5917	434.8937
.5	95.0334	87.1139	.5	283.5294	448.9215
.6	98.5205	91.9525	.6	289.5298	463.2477
.7	102.0705	96.9670	.7	295.5931	477.7755
.8	105.6834	102.1606	.8	301.7192	492.8081
.9	109.3590	107.5364	.9	307.9082	508.0485
6.0	113.0976	113.0976	10.0	314.1600	523.6000
.1	116.8989	118.8472	.1	320.4746	539.4656
.2	120.7631	124.7885	.2	326.8520	555.6485
.3	124.6901	130.9246	.3	333.2923	572.1518
.4	128.6799	137.2585	.4	339.7954	588.9784
.5	132.7326	143.7936	.5	346.3614	606.1324
.6	136.8480	150.5329	.6	352.9901	623.6159
.7	141.0264	157.4795	.7	359.6817	641.4325
.8	145.2675	164.6365	.8	366.4362	659.5852
.9	149.5715	172.0073	.9	373.2534	678.0771
7.0	153.9384	179.5948	11.0	380.1336	696.9116
.1	158.3680	187.4021	.1	387.0765	716.0915
.2	162.8605	195.4326	.2	394.0823	735.6200
.3	167.4158	203.6893	.3	401.1509	755.5008
.4	172.0340	212.1752	.4	408.2823	775.7364
.5	176.7150	220.8937	.5	415.4766	796.3301
.6	181.4588	229.8478	.6	422.7336	817.2851
.7	186.2654	239.0511	.7	430.0536	838.6045
.8	191.1349	248.4754	.8	437.4363	860.2915
.9	196.0672	258.1552	.9	444.8819	882.3492
			12.0	452.3904	904.7808

TABLE XII,

Containing the squares, cubes, superficies, and solid content of spheres, from ½ inch to 12 inches, advancing by an eighth.

Diam.	Squares.	Cubes.	Superficies.	Solidity.
½	.25	.125	.7854	.0654
⅝	.390625	.244140625	1.2271	.1278
¾	.5625	.421875	1.7671	.2208
⅞	.765625	.669921875	2.4052	.3507
1 *in.*	1	1	3.1416	.5236
⅛	1.265625	1.423818125	3.9760	.7455
¼	1.5625	1.953125	4.9087	1.0226
⅜	1.890625	2.599609375	5.9395	1.3611
½	2.25	3.375	7.0686	1.7671
⅝	2.640625	4.291015625	8.2957	2.2467
¾	3.0625	5.359375	9.6211	2.8061
⅞	3.515625	6.591796875	11.0446	3.4514
2 *in.*	4	8	12.5664	4.1888
⅛	4.515625	9.595703125	14.1862	5.0243
¼	5.0625	11.390625	15.9043	5.9640
⅜	5.640625	13.39648375	17.7205	7.0143
½	6.25	15.625	19.6350	8.1812
⅝	6.890625	18.087890625	21.6475	9.4708
¾	7.5625	20.796875	23.7583	10.8892
⅞	8.265625	23.763671875	25.9672	12.4426
3 *in.*	9	27	28.2744	14.1372
⅛	9.765625	30.517578125	30.6796	15.9790
¼	10.5625	34.328125	33.1831	17.9742
⅜	11.390625	38.443359375	35.7847	20.1289
½	12.25	42.875	38.4846	22.4493
⅝	13.140625	47.634765625	41.2825	24.9415
¾	14.0625	52.734375	44.1787	27.6117
⅞	15.015625	58.185546875	47.1730	30.4659
4 *in.*	16	64	50.2656	33.5104
⅛	17.015625	70.189453125	53.4562	36.7511
¼	18.0625	76.765625	56.7451	40.1944
⅜	19.140625	83.740234375	60.1321	43.8463
½	20.25	91.125	63.6174	47.7127
⅝	21.390625	98.931640625	67.2007	51.8006
¾	22.5625	107.171875	70.8823	56.1151
⅞	23.765625	115.857421875	74.6620	60.6629
5 *in.*	25	125	78.5400	65.4500
⅛	26.265625	134.611328125	82.5160	70.4824
¼	27.5625	144.703125	86.5903	75.7664
⅜	28.890625	155.287109375	90.7627	81.3083
½	30.25	166.375	95.0334	87.1139
⅝	31.640625	177.978515625	99.4021	93.1875
¾	33.0625	190.109375	103.8691	99.5412
⅞	34.515625	202.779296875	108.4342	106.1754

Diam.	*Squares.*	*Cubes.*	*Superficies.*	*Solidity.*
6 *in.*	36	216	113.0976	113.0976
⅛	37.515625	229.783203115	117.8590	120.3139
¼	39.0625	244.140625	122.7187	127.8320
⅜	40.640625	259.083984375	127.6765	135.6563
½	42.25	274.625	132.7326	143.7936
⅝	43.890625	290.775390625	137.8867	152.2499
¾	45.5625	307.546875	143.1391	161.0315
⅞	47.265625	324.951171875	148.4896	170.1682
7 *in.*	49	343	153.9384	179.5948
⅛	50.765625	361.704078125	159.4852	189.3882
¼	52.5625	381.078125	165.1303	199.5325
⅜	54.390625	401.130859375	170.8735	210.0331
½	56.25	421.875	176.7150	220.8937
⅝	58.140625	443.322265625	182.6545	232.1235
¾	60.0625	465.484375	188.6923	243.7276
⅞	62.015625	488.373046875	194.8282	255.7121
8 *in.*	64	512	201.0624	268.0832
⅛	66.015625	536.376953125	207.3946	280.8469
¼	68.0625	561.515625	213.8251	294.0095
⅜	70.140625	587.427734375	220.3537	307.5771
½	72.25	614.125	226.9806	321.5553
⅝	74.390625	641.619140625	233.7055	335.9517
¾	76.5625	669.921875	240.5287	350.7710
⅞	78.765625	699.044921875	247.4500	366.0199
9 *in.*	81	729	254.4696	381.7017
⅛	83.265625	759.798828125	261.5872	397.8306
¼	85.5625	791.453125	268.8031	414.4048
⅜	87.890625	823.974609375	276.1171	431.4361
½	90.25	857.375	283.5294	448.9215
⅝	92.640625	891.666015625	291.0397	466.8763
¾	95.0625	926.859375	298.6483	485.3035
⅞	97.515625	962.966796875	306.3550	504.2094
10 *in.*	100	1000	314.1600	523.6000
⅛	102.515625	1037.970703125	322.0630	543.4814
¼	105.0625	1076.890625	330.0643	563.8603
⅜	107.640625	1116.771448375	338.1637	584.7415
½	110.25	1157.625	346.3614	606.1318
⅝	112.890625	1199.462890625	354.6571	628.0387
¾	115.5625	1242.296875	363.0511	650.4666
⅞	118.265625	1286.138671875	371.5432	673.4222
11 *in.*	121	1331	380.1336	696.9116
⅛	123.765625	1376.892578125	388.8220	720.9409
¼	126.5625	1423.828125	397.6087	745.5004
⅜	129.390625	1471.818359375	406.4935	770.6440
½	132.25	1520.875	415.4766	796.3301
⅝	135.140625	1571.009765625	424.5576	822.5807
¾	138.0625	1622.234375	433.7371	849.4035
⅞	141.015625	1674.560546875	443.0146	876.7999
12 *in.*	144	1728	452.3904	904.7808

FORMATION OF THE PRECEDING TABLES.

In calculating the preceding tables of circumferen squares, cubes, areas, &c., the following simple r have been adopted :—

1. *The circumferences.*

The circumferences were obtained by adding $\frac{1}{8}$ 3.1416, or .3927 constantly for the first table; $\frac{1}{10}$ 3.1416, or .31416 for the second; and $\frac{1}{12}$ or .2618 the third table; thus,

The circumference of a circle, whose diameter is

$$
\begin{array}{rl}
1 & = 3.1416 \\
 & + \ \ .3927 \\
\hline
1\frac{1}{8} & = 3.5343 \\
 & + \ \ .3927 \\
\hline
1\frac{1}{4} & = 3.9270 \\
 & + \ \ .3927 \\
\hline
1\frac{3}{8} & = 4.3197, \text{ \&c.}
\end{array}
$$

Again,

$$
\begin{array}{rl}
1 & = 3.1416 \\
 & + \ \ .31416 \\
\hline
1.1 & = 3\ 45576 \\
 & + \ \ .31416 \\
\hline
1.2 & = 3.76992 \\
 & + \ \ .31416 \\
\hline
1.3 & = 4.08408, \text{ \&c.}
\end{array}
$$

Also,

$$
\begin{array}{rl}
1 \text{ foot} & = 3.1416 \\
 & + \ \ .2618 \\
\hline
1.0833 & = 3.4034 \\
 & + \ \ .2618 \\
\hline
1.1666 & = 3.6652 \\
 & + \ \ .2618 \\
\hline
1.25 & = 3.9270, \text{ \&c.}
\end{array}
$$

2. *The squares.*

After the first square of each succeeding series was found by the common rule, twice the root of that square, plus 1, added to the square number obtained, gave the square of the next number required; thus,

$$\begin{array}{llrl}
\text{The square of} & 1.1 = & 1.21 & \\
\text{And} \quad 1.1 \times 2 + 1 = & & 3.2 & + \\
\hline
 & & 4.41 & = \text{the square of } 2.1 \\
2.1 \times 2 + 1 = & & 5.2 & + \\
\hline
 & & 9.61 & = \text{the square of } 3.1 \\
3.1 \times 2 + 1 = & & 7.2 & + \\
\hline
 & & 16.81 & = \text{the square of } 4.1, \&c.
\end{array}$$

$$\begin{array}{llrl}
\text{Again the square of} & 1.2 = & 1.44 & \\
\text{And} & 1.2 \times 2 + 1 = & 3.4 & + \\
\hline
 & & 4.84 & = \text{the square of } 2.2 \\
 & 2.2 \times 2 + 1 = & 5.4 & + \\
\hline
 & & 10.24 & = \text{the square of } 3.2 \\
 & 3.2 \times 2 + 1 = & 7.4 & + \\
\hline
 & & 17.64 & = \text{the square of } 4.2, \&c.
\end{array}$$

3. *The cubes.*

In finding the cubes, the first of each series was also found in the usual form, then the root of the number so obtained being multiplied by 3, and by the root of the number required, and the product, plus 1, added to the former cube, gave the cube of the next number required; thus,

$$\begin{array}{llrl}
 & \text{The cube of } 1.1 = & 1.331 & \\
\text{And} & 1.1 \times 3 \times 2.1 + 1 = & 7.93 & + \\
\hline
 & & 9.261 & = \text{the cube of } 2.1 \\
 & 2.1 \times 3 \times 3.1 + 1 = & 20.53 & + \\
\hline
 & & 29.791 & = \text{the cube of } 3.1 \\
 & 3.1 \times 3 \times 4.1 + 1 = & 39.13 & + \\
\hline
 & & 68.921 & = \text{the cube of } 4.1, \&c.
\end{array}$$

Or the cube of 1.2 = 1.728
And 1.2 × 3 × 2.2 + 1 = 8.92 +
10.648 = the cube of 2.2
2.2 × 3 × 3.8 + 1 = 22.12 +
32.768 = the cube of 3.2
3.2 × 3 × 4.2 + 1 = 41.32 +
74.088 = the cube of 4.2, &c.

4. *The areas.*

After the first area of each succeeding series was obtained by the common rule, the others were found by the following, namely, a table of constant numbers was formed by multiplying .7854 by twice the fractional number contained in the diameter; thus,

⅛ × 2 = .25 × .7854 = .19635
¼ × 2 = .5 × .7854 = .3927
⅜ × 2 = .75 × .7854 = .58905
½ × 2 = 1 × .7854 = .7854
⅝ × 2 = 1.25 × .7854 = .98175
¾ × 2 = 1.5 × .7854 = 1.1781
⅞ × 2 = 1.75 × ·7854 = 1.37445 for the first table.

.1 × 2 = .2 × .7854 = .15708
.2 × 2 = .4 × .7854 = .31416
.3 × 2 = .6 × .7854 = .47124
.4 × 2 = .8 × .7854 = .62832
.5 × 2 = 1 × .7854 = .7854
.6 × 2 = 1.2 × .7854 = .94248
.7 × 2 = 1.4 × .7854 = 1.09956
.8 × 2 = 1.6 × .7854 = 1.25664
.9 × 2 = 1.8 × .7854 = 1.41372 for the second.

And, .0833 × 2 = .1666 × .7854 = .13084764
.1666 × 2 = .3333 × .7854 = .26177382
.25 × 2 = .5 × .7854 = .3927
.3333 × 2 = .6666 × .7854 = .52354764
.4166 × 2 = .8333 × .7854 = .165447382
.5 × 2 = 1 × .7854 = .7854
.5833 × 2 = 1.1666 × .7854 = .91624764
.6666 × 2 = 1.3333 × .7854 = 1.04717382
.75 × 2 = 1.5 × .7854 = 1.1781
.8333 × 2 = 1.6666 × .7854 = 1.30894764
.9166 × 2 = 1.8333 × .7854 = 1.43987382 for the third *table, &c.*

Then twice the whole numbers of the first circle plus 1, and multiplied by .7854, produced a sum which, when added to the area and constant number of the fractional part, gave the area of the next in the series; thus,

The area of a circle whose diameter is $1\frac{1}{8}$
= .994021875
And $1 \times 2 + 1 = 3 \times .7854 = 2.3562$
+the constant number .19635

3.546571875=the area of $2\frac{1}{8}$
$2 \times 2 + 1 = 5 \times .7854 = 3.927$
+ .19635

7.669921875=the area of $3\frac{1}{8}$
$3 \times 2 + 1 = 7 \times .7854 = 5.4978$
+ .19635

13.364071875=the area of $4\frac{1}{8}$, &c.

Again, the area of $1\frac{1}{4}$ = 1.2271875
To which add as above, 2.3562
And the constant number .3927

3.9760875 = the area of $2\frac{1}{4}$.
3.927
.3927

8.2957875 = the area of $3\frac{1}{4}$.
5.4978
.3927

14.1862875 = the area of $4\frac{1}{4}$, &c.

RULES

FOR MAKING OR CORRECTING THE GAUGE POINTS ON THE ENGINEER'S SLIDE RULE.

The engineer's slide rule is an instrument of extensive use to mechanics, and almost every one who is in possession of the rule, is also, or may be, in ample possession of instructions; but I am not aware that any information has been given in any other work, for either correcting the old gauge points, or obtaining new ones; hence the following may be found useful:—

And first, by making the third column on the rule (or that marked III) the first of our observations, the others are rendered very simple; thus,

The third column is the number of cubic inches contained in a lb., foot, gallon, &c.

The second column is the numbers in the third column expressed in the decimals of a foot, or multiplied by .833.

The first column is the third column divided by 1728.

The fifth column is the third column divided by .7854.

The fourth column is the fifth column expressed in the decimals of a foot, or multiplied by .833.

The seventh column is the third column divided by .5236. And,

The 6th column is the 7th column divided by 1728.

DECIMAL APPROXIMATIONS FOR FACILITATING CALCULATIONS IN MENSURATION.

Lineal	feet	multiplied by	.00019	=	miles.	
„	yards	„	.000568	=	„	
Square	inches	„	.007	=	square feet.	
„	yards	„	.0002067	=	acres.	
Circular	inches	„	.00546	=	square feet.	
Cylindrical	inches	„	.0004546	=	cubic feet.	
„	feet	„	.02909	=	cubic yards.	
Cubic	inches	„	.00058	=	cubic feet.	
„	feet	„	.03704	=	cubic yards.	
„	„	„	6.232	=	imperial gallons.	
„	inches	„	.003607	=	„	„
Cylindrical	feet	„	4.895	=	„	„
„	inches	„	.002832	=	„	„
Cubic	inches	„	.263	=	lbs. av.[s]	of cast iron.
„	„	„	.281	=	„	wrought do.
„	„	„	.283	=	„	steel.
„	„	„	.3225	=	„	copper.
„	„	„	.3037	=	„	brass.
„	„	„	.26	=	„	zinc.
„	„	„	.4103	=	„	lead.
„	„	„	.2636	=	„	tin.
„	„	„	.4908	=	„	mercury.
Cylindrical	inches	„	.2065	=	„	cast iron.
	„	„	.2168	=	„	wrought iron.
	„	„	.2223	=	„	steel.
	„	„	.2533	=	„	copper.
	„	„	.2385	=	„	brass.
	„	„	.2042	=	„	zinc.
	„	„	.3223	=	„	lead.
	„	„	.207	=	„	tin.
	„	„	.3854	=	„	mercury.
Avoirdupois	lbs.	„	.009	=	cwts.	
„	„	„	.00045	=	tons.	

DECIMAL EQUIVALENTS TO FRACTIONAL PARTS OF LINEAL MEASURES.

One inch, the integer or whole number.

	are equal to		are equal to		are equal to
.96875	7/8 & 3/32	.625	5/8	.28125	1/4 & 1/32
.9375	7/8 & 1/16	.59375	1/2 & 3/32	.25	1/4
.90625	7/8 & 1/32	.5625	1/2 & 1/16	.21875	1/8 & 3/32
.875	7/8	.53125	1/2 & 1/32	.1875	1/8 & 1/16
.84375	3/4 & 3/32	.5	1/2	.15625	1/8 & 1/32
.8125	3/4 & 1/16	.46875	3/8 & 3/32	.125	1/8
.78125	3/4 & 1/32	.4375	3/8 & 1/16	.09375	3/32
.75	3/4	.40625	3/8 & 1/32	.0625	1/16
.71875	5/8 & 3/32	.375	3/8	.03125	1/32
.6875	5/8 & 1/16	.34375	1/4 & 3/32		
.65625	5/8 & 1/32	.3125	1/4 & 1/16		

One foot, or 12 inches, the integer.

	are equal to		are equal to		are equal to
.9166	11 inches.	.4166	5 in.	.0625	3/4 of in.
.6333	10 "	.3333	4 "	.0528	5/8 "
.75	9 "	.25	3 "	.04166	1/2 "
.6666	8 "	.1666	2 "	.03125	3/8 "
.5833	7 ,	.0833	1 "	.02083	1/4 "
.5	6 "	.07291	7/8 "	.01041	1/8 "

One yard, or 36 inches, the integer.

	are equal to		are equal to		are equal to
.9722	35 inches.	.6389	23 inches.	.3055	11 inches.
.9445	34 "	.6111	22 "	.2778	10 "
.9167	33 "	.5833	21 "	.25	9 "
.8889	32 "	.5556	20 "	.2222	8 "
.8611	31 "	.5278	19 "	.1944	7 "
.8333	30 "	.5	18 "	.1666	6 "
.8056	29 "	.4722	17 "	.1389	5 "
.7778	28 "	.4445	16 "	.1111	4 "
.75	27 "	.4166	15 "	.0833	3 "
.7222	26 "	.3889	14 "	.0555	2 "
.6944	25 "	.3611	13 "	.0277	1 "
.6667	24 "	.3333	12 "		

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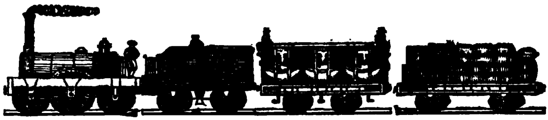

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